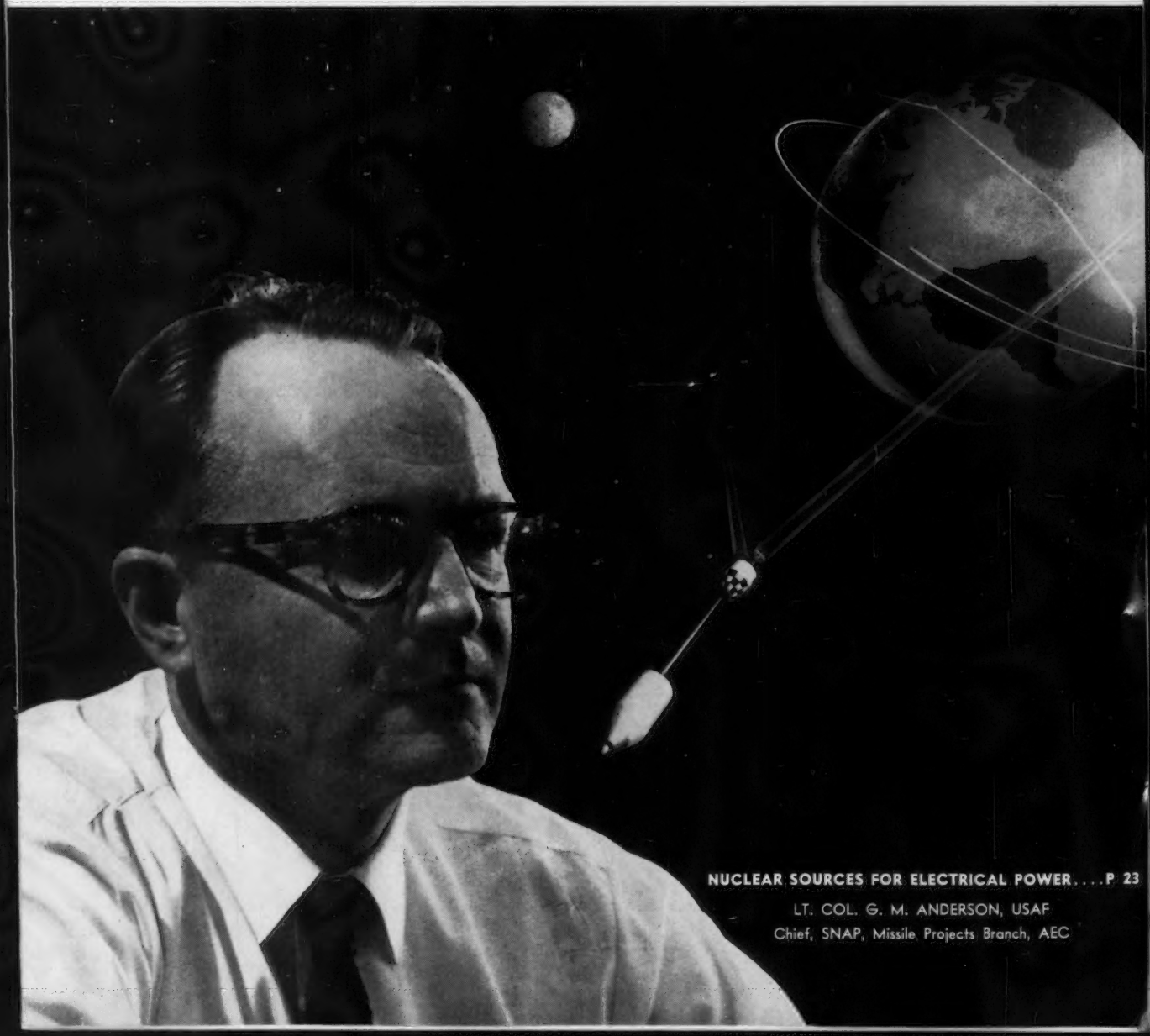
AIRCRAFT & MISSILES

A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES May 1961

SPACE RACE LEAPFROG URGED WITH NUCLEAR ENGINES . . . P 36

Design Directions For Nuclear Rocket Revealed . . . P 41

VICIOUS PROCUREMENT PRACTICES–SITUATION WORSENS . . . P 52



NUCLEAR SOURCES FOR ELECTRICAL POWER. . . . P 23

LT. COL. G. M. ANDERSON, USAF
Chief, SNAP, Missile Projects Branch, AEC

Nowhere is this closeness more apparent than at Lockheed. Here, with each passing day, new technological advances help bring nearer the exploration of Mars, the Moon and Venus.

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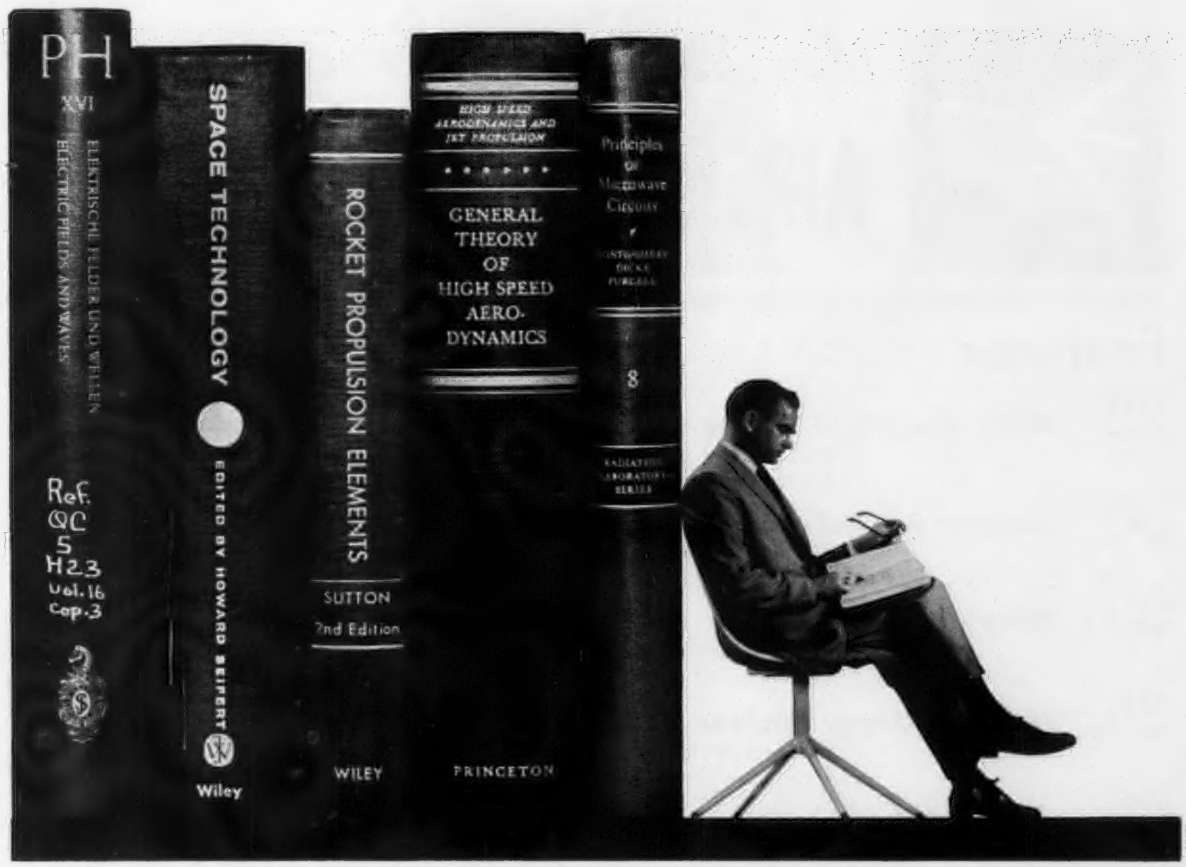

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May, 1961 *Volume 4, Number 5*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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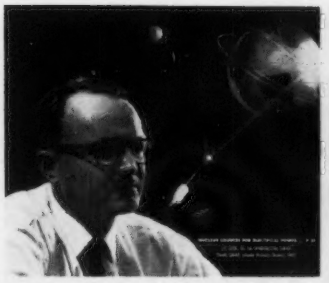
THE COVER STORY—The advent of nuclear power on Earth is now changing man's destiny. In the coming decades, nuclear power-packages in satellites may play an equally-vital role. Depicted on this month's cover is a communications-satellite network powered by electricity derived from nuclear systems. Pictured is Lt. Col. G. M. Anderson, USAF, chief, Systems for Nuclear Auxiliary Power (SNAP), Missile Projects Branch, AEC. His status report starts on page 23.



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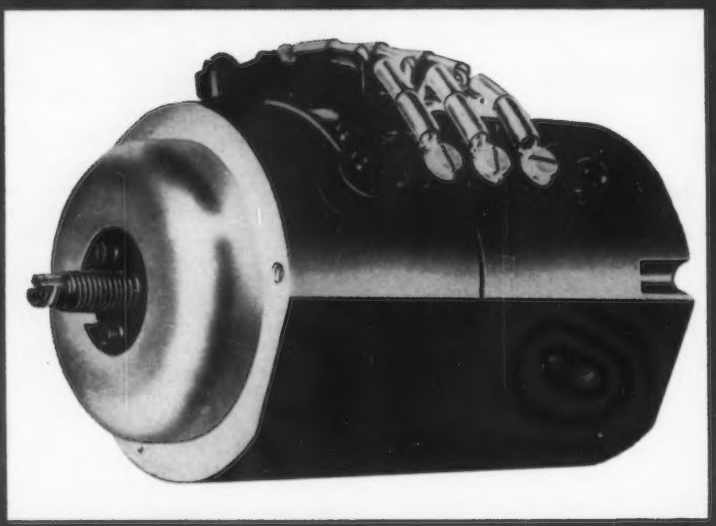

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National Aerospace Electronics Conference
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Western Joint Computer Conference and Exhibit
Ambassador Hotel
Los Angeles, Calif.

May 15-17
National Symposium on Microwave Theroy and Techniques
IRE—Sheraton Park Hotel
Washington, D. C.

May 22-24
National Telemetering Conference
Sheraton Towers Hotel
Chicago, Ill.

May 22-24
Fifth National Symposium on Global Communications
Institute of Radio Engineers
Hotel Sherman, Chicago

May 8-9
Lubrication Symposium
American Society of Mechanical Engineers
Hotel Deauville, Miami Beach, Fla.

May 7-11
Hydraulics Conference
American Society of Mechanical Engineers and The Engineering Institute of Canada
Queen Elizabeth Hotel, Montreal, Canada

May 10-12
Production Engineering Conference
American Society of Mechanical Engineers
Royal York Hotel, Toronto, Canada

May 22-25
Design Engineering Conference and Show
American Society of Mechanical Engineers
Cobo Hall, Detroit, Mich.

May 15-18
20th Annual National Conference of the Society of Aeronautical Weight Engineers
Sheraton Hotel, Akron, Ohio

June 5-9
Ninth National Plastics Exposition
The Society of the Plastics Industry
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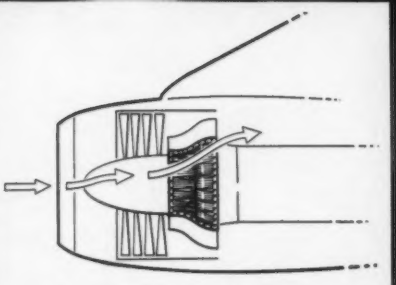
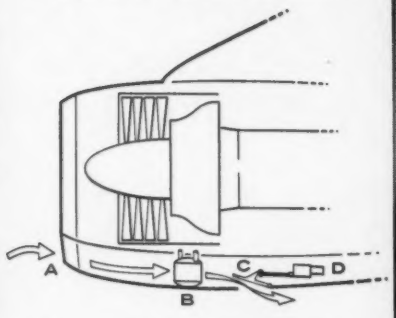


Multicontoured oil cooler is section of fan exhaust duct



Conventional oil cooling system includes: A. Duct B. Heat exchanger C. Door D. Actuator

This finned surface oil cooler, used for cooling constant speed drive or turbocompressor lubrication oil circuits, is a structural member of the fan exhaust duct. This eliminates the need for air scoops and special ducting.

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Let's Get Organized

Russia has known where it is going and what it is doing with its space program from the outset. The successful orbit and recovery of man on April 12, 1961, ranks with Sputnik I. These are the two most significant space-age accomplishments. And they are both on the Russian ledger. The Russians have pursued the goal of placing a man in space with a dogged, methodical determination. The U.S. space program has not had the same resoluteness. There has been a lot of activity by a lot of people. That they are all working together is not always obvious.

Would a Secretary of Aeronautics and Space add confusion to the U.S. space problems? Still after three years (since the politicos discovered space) and the first 120 days of the New Frontier, we're not quite sure which department has what and why.

Air Force is said to be in control of military space. Yet, just recently, Navy wants shipborne satellite launchers. Army, on the other hand, is said to be in control of space reconnaissance. NASA lays claim to civil space. Curiosity aroused? Sure, where does military space leave off and civil space begin or vice versa? Also, does Air Force have charge of military space?

Establishment of a new department with Secretarial status is not necessarily the answer to the muddled chain of command. Bill S.1408, proposing a Secretary of Aeronautics and Space and a department thereof, is certainly a worthy gesture to put Space on the same plane as State, Defense, Treasury, etc. But, there's more confusion.

According to the bill, the new Secretary will have the authority over programs for the development of aeronautical and space vehicles and activities as he (the Secretary) may determine to be in the national interest. S.1408 claims that the terms aeronautical and space vehicles and activities shall have the same meaning given to them by section 103 of the National Aeronautics and Space Act of 1958.

Yet, in the next breath, S.1408 transfers to the new Secretary such functions, powers, and duties of the Sec'y of Defense, the Dept. of Defense, et al, as the President shall determine to relate to the aeronautical and space activities not peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the U.S. (including R&D). Wasn't this supposed to have been done already?

OK, it would probably be a good idea to upgrade NASA to Department status with a cabinet member as its head. This would still leave the President as the only arbiter between DOD and NASA. Perhaps, we need a departure from the norm. Why not put the Vice President in charge of both Departments? His responsibility would be the conquest of space, whether civil or military.

Tom MacNew
Editor

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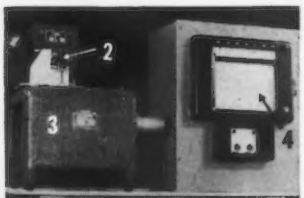

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Reader's Orbit

The Best Defense

. . . Your provocative editorial (April 1961) "Are Free Seas Worth Another $ Billion?" should produce comment. Perhaps the key to increasing the attention which must be given in order to maintain U. S. leadership in "inner space" lies in your words "anti-submarine offense." One rarely associates the classic military philosophy that "the best defense is a good offense" with the ASW problem. History shows that military programs which are aimed at strengthening our offensive capabilities receive more support than those which are purely defensive.

J. V. Ellison
Research Department
McDonnell Aircraft Corp.

Right Facts, Wrong Conclusion

. . . Naive, expensive, and unprofessional is the approach to missile reliability suggested by the lead article in your April, 1961, issue. Author Ellis in his article, "The Fight for Purchased Parts Quality," implies that parts manufacturers are not too concerned about quality and reliability of their products; that they espouse the policy of *caveat emptor:* and that quality assurance people at the missile assembly plants stand alone as the saviors of component reliability.

Author Ellis is probably accurate in his summaries of purchasing and inspection by the eight (8) different contractors but the facts recited lead to a conclusion altogether different from the one he emphasizes.

In his account of each company, there is either a direct or implied suggestion that MIL-Specs are generally worthless and must be replaced by company Specs plus dozens of QC people performing receiving inspections to diverse test Specs generated by themselves. This procedure, it is said, plus a blacklisting of suppliers will make parts manufacturers jolly well "gung ho" on quality.

It is hoped that most of your readers will recognize author Ellis' suggestions as nothing more than a vulgar travesty of the Defense Standardization Program and that adherence by all concerned to the true and venerable policies expressed in Defense Standardization Manual, M-200, will do the job better and at much lower cost.

Give the parts manufacturers a chance at fair competition through MIL-Specs properly amended or revised; give them standardized requirements, test and sampling plans with thorough inspection at source. Quality will be achieved and the cost of QUET will be cut by a factor of 10 or more.

Let the QC people in the missile plants tend to their own knitting. What have they done lately to bring MIL-Specs into line with requirements of modern weaponry?

Samuel E. McCrary, P. E.
Huntsville, Alabama

Plastic Polaris

. . . just received my copy of Aircraft & Missiles and am quite interested in the article on Navy's plans to produce a "Plastic Polaris" . . . this article is also of interest to a number of our technical, management, and sales people . . . if you can arrange to send us several copies of the article I can assure you they will be put to good use. . . .

F. William Jahns, Jr.
Senior Engineer
Continental Diamond Fibre Corp.

Man-In-Space

. . . (re Mercury picture story February, 1961) . . . the pictures do give some idea of what is sometimes called the simple Mercury capsule . . . appreciate your bringing the Mercury story before your readers.

Hugh L. Dryden
Deputy Administrator
NASA

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A. M. Johnson, Jr.
Asst. Marketing Manager
Beckman Systems Div.

New Books

PHOTOCHEMISTRY IN THE LIQUID AND SOLID STATES. Edited by: Lawrence J. Heidt, Robert S. Livingston, Eugene Roabinowitch, and Farrington Daniels. Wiley, 1960. 174 pp. $6.00. This book contains some of the papers presented at a symposium held at Endicott House in Dedham, Mass., Sept. 3 to 7, 1957. Chapter coverage includes: photochemical reactions, photosensitized reactions, fluorescence, kinetic considerations, role of the triplet state, photochemical reactions involving chlorophyll, and photoreactions in solids.

CONTROLLING RADIATION EMERGENCIES (TID-8206 (Rev.). Compiled and Edited by Allen Brodsky and G. Victor Beard, 1960, 100 pp., $1.00. Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. This publication contains a summary of the lecture material presented during a radiological assistance training course held in February, 1958, at Idaho Falls, Idaho, for Commission, contractor, Armed Forces, Federal, and State personnel who have responsibilities for minimizing the effects of incidents involving radioactive materials. Also included is a compendium of data and information for use during emergencies, or in emergency planning, and a reference list of 184 publications on the subject of radiation and its control.

SURFACE EFFECTS ON SPACECRAFT MATERIALS. Edited by: Francis J. Clauss. Wiley, 1960. 404 pp. $11.50. Transactions of the symposium co-sponsored by the Missiles and Space Div., Lockheed Aircraft Corp., and Air Research and Development Command, U. S. Air Force, Palo Alto, Cal., May 12 and 13, 1959. The temperature-control problem and the effect of environmental conditions of space on materials are the focal subjects of these studies. Topics discussed include: coatings for space vehicles, reflectance measurements, emissivity of materials, sublimation in high vacuum, surface phenomena and friction, ultraviolet solar radiation, interplanetary dust distribution and erosion effect, atomic and molecular sputtering.

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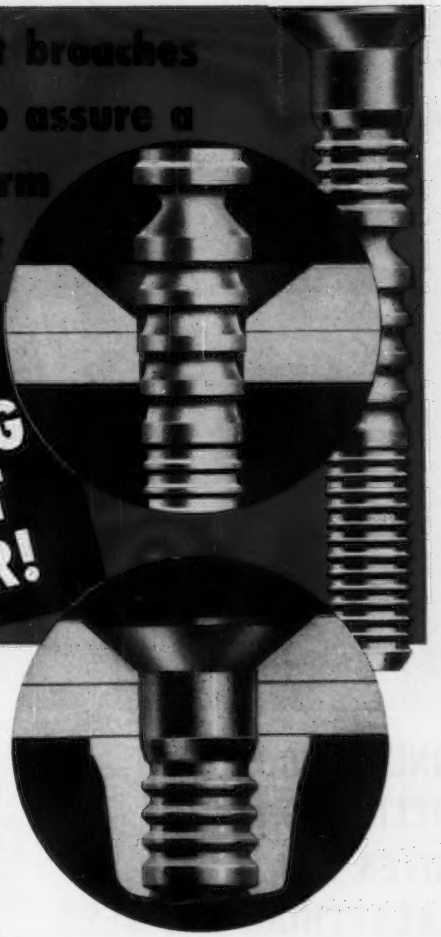

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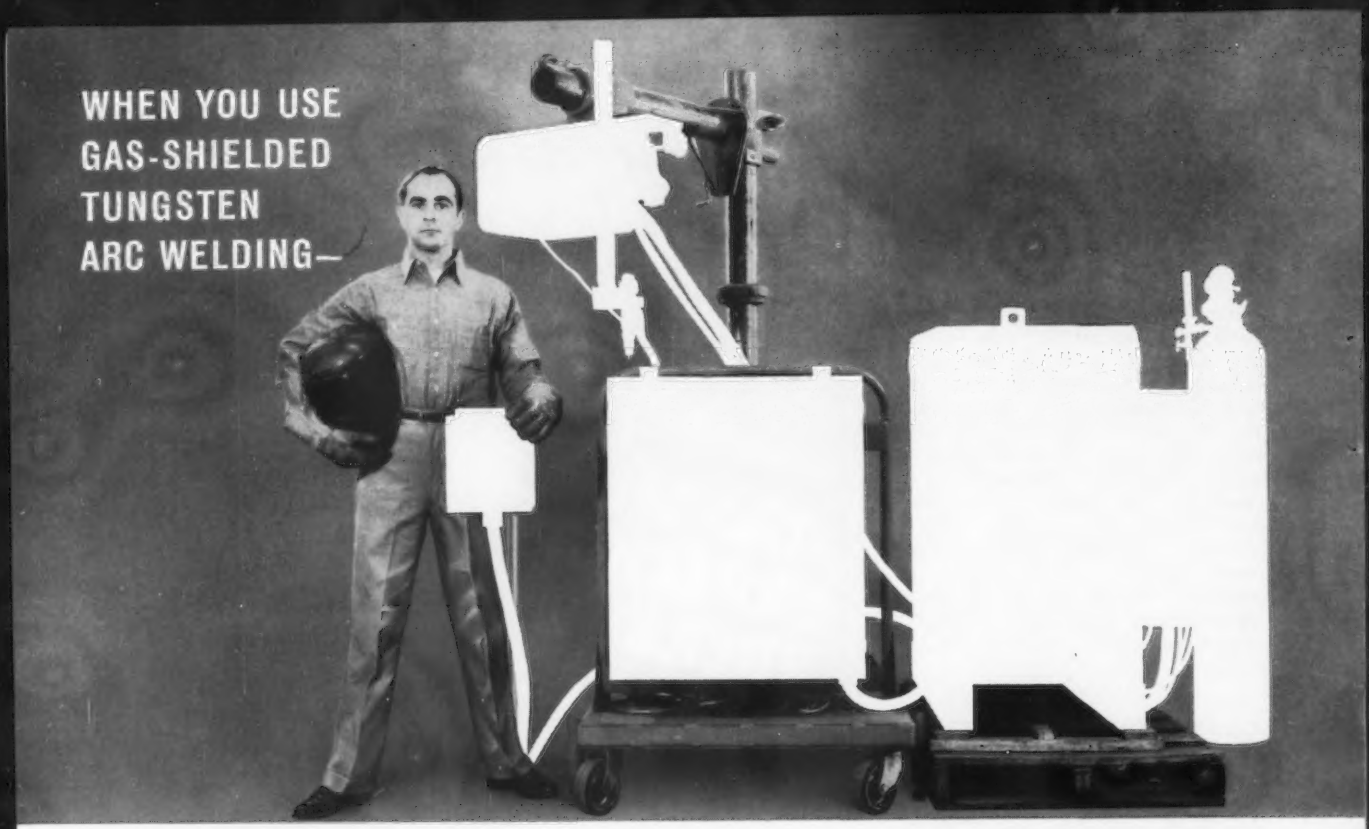

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MISSILES AND SPACE VEHICLES

AERIE--Weapon system proposed by Bendix would use modified KC-135's equipped with search and acquisition radars, and a battle center to direct more than two dozen Eagle missiles to target.

APOLLO--Preliminary studies due to be completed this month. First test flights scheduled for 1964 with active flight testing and mission flights in the 1965 to 1970 period.

DYNA-SOAR--Plasma sheath (super hot air) surrounding vehicle during expected half hour Mach 20 flight may complicate communications.

Secondary guidance subsystem by Minneapolis Honeywell consists of a stable platform, platforms electronics, and platform attitude programmer. Subsystem is used mainly in case primary guidance fails.

EAGLE MISSILEER--Navy's program for fleet defense with special missiles scheduled for abandonment.

MADREC--System (MAlfunction Detection and RECording), developed for Air Force by Lockheed, will initially be used on B-52 and B-47 to detect and record the cause of "bugs" or "squawks" in the complex systems even during flight.

MARS--Ten lb fresh air machine, the size of a loaf of bread, developed by General Dynamics will keep three American astronauts breathing comfortably for nearly a month in their Manned Astronautical Research Station.

MAULER--New electro hot-gas servo (being developed for the Army by Weston Hydraulics, Ltd.) uses hot gases expended by a solid propellant cartridge to power the unit. Unit is low weight, and can be stored for long periods without deterioration.

MIDAS PIGGYBACK--Air Force considering development of radiation-measurement satellites to be launched piggyback on Midas infrared ICBM-early-warning satellites.

MINUTEMAN--Budget calls for doubling of present production with three squadrons going to underground sites.

NIKE ZEUS--Antiballistic missile defense system is undergoing critical capability tests before full-scale production order is given by DOD.

PERSHING--All-plastic nozzles are being developed for Pershing's first and second stage rocket motors (Dumont Mfg. Co. is subcontractor for Thiokol Chemical).

POLARIS--President Kennedy's budget asks for 19 new Polaris submarines during FY 1961 with general increased production thereafter to bring the total of operational Polaris subs to 29 by 1964.

PROSPECTOR--NASA plans to let design study contracts this year and development contracts by mid-1962.

S-15 SATELLITE--NASA will launch, in the near future, a gamma ray astronomy telescope satellite to detect and measure cosmic gamma radiation from space. The Marshall Center will use a four-stage Juno II rocket to boost the satellite into orbit.

SATURN--Westinghouse claims nuclear upper stage would double or triple payloads into orbit before 1970.

SKYBOLT--B-52 launched solid-fuel nuclear missile with 1000 mi range is budgeted for an additional $50-million.

SNARK--Missile to be abandoned under new budget.

SPACE CANARY--Project objective is to send an instrumented monkey with a human astronaut to give warning of any dangerous environmental changes in the space capsule.

Projects

AEROSPACE DATA CAPSULE I . . . continued

STAR--(Space Thermionic Auxiliary Reactor) Special project by General Electric to design a small atomic electric power plant for space use. Concentration is on design of compact, lightweight nuclear power plant utilizing thermionic devices to convert nuclear heat directly into electrical power.

TARTAR--Two speed solid motor in production at Aerojet General for Navy surface-to-air missile. Dual grain propellant produces high thrust for takeoff then burn rate slows to give extra range. Higher impulse propellants being developed for later systems.

TITAN--President's budget schedules elimination of two squadrons.

WIND SONDE--Air-launched weather missile measures wind direction and velocity at a wide range of altitudes; might also be used in exploring other planetary atmospheres. Missile is monitored by launch-aircraft. Boeing's Allied Research Associates is developing the missile for civilian and military use.

AIRCRAFT

B-47--Budget calls for continued cutbacks and early phase-out.

B-70--New budget calls for bomber to be dropped as a major weapons system.

BOEING HELICOPTER ENGINE--T50-B0-4 earmarked for Navy DSN-3 drone has passed 150 hour qualification test.

C-130A HERCULES--Modifications will begin soon on several of these turboprop transports to accommodate instrument for tracking Polaris missiles. Temco Electronics and Missiles Co. will modify the aircraft which will be used on the Atlantic Missile Range.

CHINOOK--Production beginning at Vertol on 18 of the HC-1B twin-turbine helicopter for the Army. First delivery is scheduled for March, 1962.

F-105--Under new budget, the fighter plane will be modified to improve its usefullness on all kinds of landing strips.

H-43--Kaman Aircraft successfully flight tested a helicopter with an all glass fiber rotor blade.

HILLER 12E--Three place helicopters ordered by Canadian Services. Twenty one go to Army and three to Air Force.

LASA 60--Lockheed designed Mexican built multi-purpose light plane now licensed for production in Italy and Argentina by Lockheed International affiliates.

LOCKHEED CX-1--New turbofan-powered transport (Air Force SOR 182) will be capable of transporting 60,000 lbs of cargo 3400 mi. Lockheed's Georgia Div. will build more than 100 for MAT fleet.

MAN-POWERED AIRCRAFT--The Royal Aeronautical Society is giving financial assistance to two groups for research and development of a man-powered aircraft. The Man-Powered Aircraft Committee found preliminary studies to be worthy of further development.

NUCLEAR AIRPLANE--After spending more than $1-million on development, program will be dropped by military and transferred to the AEC.

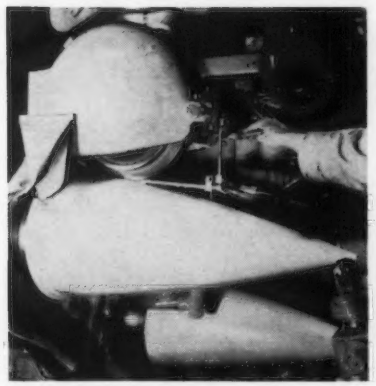
T-38 TALON--Northrop trainers with Mach 1.2 capability delivered to Air Force Air Training command. Hope for sales, of N156F Freedom fighters, based on T-38 design, have raised by U.S. "need" for light tactical fighter for brush wars.

X-15--Extension into regions never before encountered in aerodynamic flight. Proof of need for manned machine demonstrated by several systems failures which would have resulted in loss of unmanned rocket.

X-15--A proposal to develop additional X-15 rocket planes as two-place trainers for astronauts has been made by North American Aviation.

A2F-1 INTRUDER carries 30 five-hundred lb bombs in clusters of three from wing stations. Grumman's all-weather two-place aircraft is designed for carrier take off with its 15,000 lb bomb load. Nuclear weapons could be substituted.

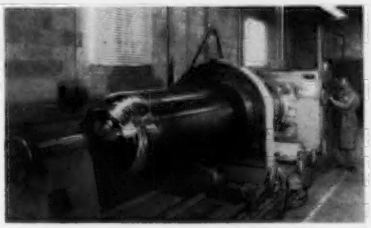
BOEING VERTOL 107 AND HC-1B helicopters in full production. On the left are two 107 transports being built as Marine light assault vehicles. Three Chinook HC-1B helicopters at right, are part of 28 ordered by Army. Both have 150 mph cruising speed.

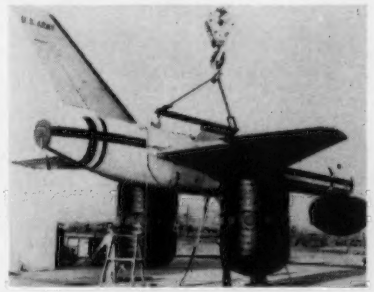


TARTAR MISSILE'S Pyroceram radomes are production ground to meet specifications by Corning Glass Works. Missile is operational.

SERGEANT rocket motor case gets four 96-in. welds in 16 min on Linde Company's circumferential welding machine. Sperry Utah welds the case from the inside. Thermal expansion of the metal forces joints tightly against backup bar for a tigher seal.

▼

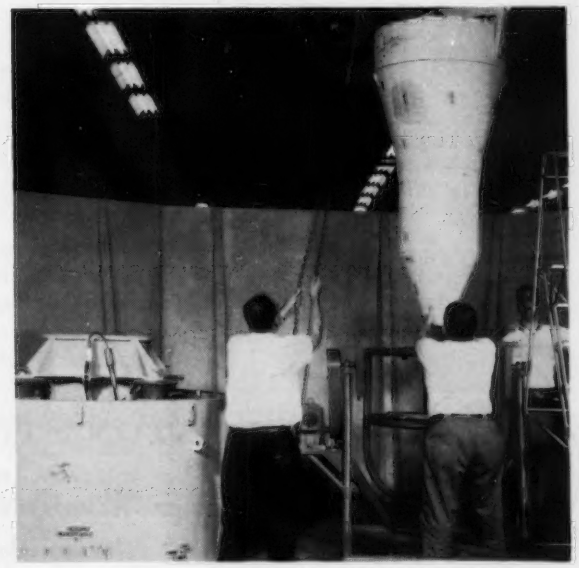




AN/USD-5 surveillance drone is being tested with drum-shaped inflatable rubber shock bags, developed by U.S. Rubber to aid in recovery. Bags "blowout" on impact, dispersing shock so drone can settle slowly to earth.

MINUTEMAN MARK 5 re-entry vehicle is hoisted from work fixture at Avco's Lycoming Div. to be packed in special shock-resistant container for shipment to the Air Force. Division is also producing larger Mark-4 for Atlas and Titan.

◀ **BIG BOOSTER** design is part of Thiokol Chemical's recommendation to NASA to develop a 3-million lb thrust solid rocket motor for boosting manned space vehicles. Proposal includes: seven solid motors for first stage, three for the second stage and liquid engines for upper stages. First stage cluster would have 44 ft diam. Vehicle would be 250 to 300 ft tall.



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Stainless Steel

Technical Advances

. AEROSPACE DATA CAPSULE 2

R&D BRIEFS

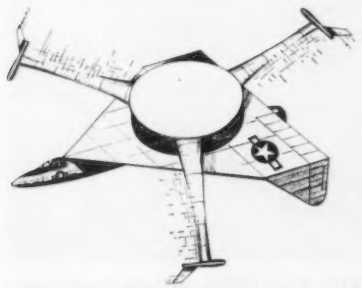
First manned space shot put Russian astronaut Major Yuri A. Gagarin into earth orbit for 108 minutes on April 12. The mercury like vehicle, Vostok, beat the planned U. S. shot by at least two weeks. The 5-ton satellite attained a speed of more than 17,000 mph. Perigee was 110 mi from earth and apogee was 188 mi.

Ultraviolet detector tube advances make possible the use of short wave-lengths in space communications. Thomas E. Edison Research Lab. developed the tube.

Ionized exhaust gases from rocket engines are being studied for use as radio antennas. They have both transmitting and receiving potential. This may open low and medium frequency bands for space communications previously ruled out because of antenna length required.

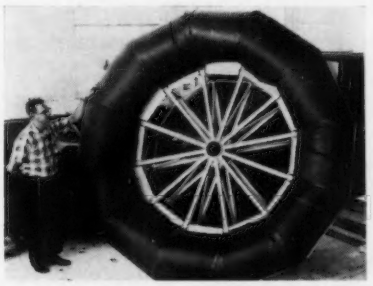
Detecting atomic gases in outer space will be the end objective of a gas analyzer study just initiated by Tracerlab for NASA.

Nuclear detector will be lowered 1925 ft below ground to shield it from cosmic activity in studying the half life of the proton, a basic nuclear particle. Case Institute will conduct the studies.



NEW ROTOR CONCEPT for helicopters utilizes flexible materials and can be "reeled-in" for fast forward flight. Vidya Inc. calls its development, Flexirotor.

Balloon drag has been shown to be a feasible way of decelerating and stabilizing space vehicles for reentry. Goodyear is building a nine-foot diam balloon for further testing.



LUNAR LANDING CUSHION proposed by Goodyear would be inflated in segments. It is made of laminated fabric and is designed to prevent bounce or upset on landing.

High-velocity electric accelerator studies by Air Force show that a small-chambered, lithium-charged, light gas gun, capable of 22,000 ft/sec velocities, is the most suitable device for high-speed particle testing.

Airborne laboratories have been designed for studying tornadoes and squall lines. First two aircraft have been completed (a DC-6 and a B-57). Program calls for 13 aircraft.

Super-power amplifiers—called klystrons—will enable two-mile long atom smasher proposed by Stanford Univ. to accelerate electrons almost to the speed of light.

New radar technique called "double bounce" makes possible absolute location and identification of aircraft. Anti-collision device is being designed by Martin using this technique.

Mass flowmeters for use with liquid hydrogen to be studied by Wyle Laboratories. Measuring instrument developed will go to Marshal Space Flight Center.

Ionizer Development — of porous tungsten ion emitters and interaction of cesium with potential ion emitter materials is subject of NASA contract to Electro-Optical Systems Inc. This is second such Company contract.

EQUIPMENT

All - weather landing device called Autoflare provides lateral and pitch guidance all the way through the landing approach to touchdown. It will undergo final flight test in 707's about September.

Magnetic storage drum with read/write heads of a special alloy has been developed by Litton Industries. Drum is cast from magnesium and then plated with nickel-cobalt alloy to provide magnetic properties.

Radiation shielding on now defunct NX-2 nuclear aircraft was being designed to keep radiation in crew compartment at .03 rem/hr.

CONTOUR CABLE developed by Hughes Aircraft Co. cuts space and weight requirements in space vehicles. Withstands 90 deg static bend and 270 deg dynamic twist.

Technical Advances

AEROSPACE DATA CAPSULE 2 . . . continued

Parasitic broadcasting device has reportedly been developed by Navy for ASW. Device magnetically attaches itself to submarine hull and begins broadcasting. These parasite radios would be strewn in known enemy submarine lanes close to home ports to effect a magnetic attachment to the sub.

Infrared terrain analyzer under study at Perkin-Elmer Corp. could be mounted in aircraft to measure ground firmness for emergency landings. This would allow pilot to make a decision on wheels-up or wheels-down landing.

Electronic "nerve system" developed by Superior Electric Co. employs Slo-Syn motor as "muscle" and a stored tape serves as the "brain." Unit can start, stop, or reverse itself 400 times/sec.

Brushless alternator developed by Thompson Ramo Woolridge Inc. is intended to generate electrical power in adverse environments. One-piece rotor has no windings or slip rings.

GATLING SHOCK TUBE being installed at Cornell Aeronautical Lab Inc. will allow model testing at 9000°F and Mach 15 for 15 sec. Each of 288 slots on drum circumference serves as shock tube at 2700 rpm.

Radar altimeters have been found to give erroneous readings over ice and snow. Certain radio frequencies will penetrate as much as 1000 ft of ice and then reflect back to the aircraft from the substrata to causing an altimeter reading 1000 ft in error.

MATERIALS

Rhenium - Molybdenum alloys can now be commercially produced with a process developed by Chase Brass & Copper Co. Aerospace electronics devices will benefit.

Ceramic fibers (continuous filament) developed by the Carborundum Co. have 132,000 psi tensile strength and withstand 1500°F. Baria - alumina - silica, calcia - alumina-silica, and magnesia-alumina-silica materials are involved.

Zinc coatings can now be applied to columbium to form an oxidation barrier. The zinc exhibits a remarkable self-repair property which automatically repairs relatively large defects in the coating. This property is associated with the high zinc vapor-pressure over the intermetallics.

Gallium arsenide transistors have been fabricated in prototype form. They will boost allowable operating environment to 400°F, and operate at higher frequencies than silicon or germanium transistors, Texas Instruments claims.

Man-made elements will be the subject of extensive study in a new, automated, nuclear chemistry laboratory at The Martin Co.'s Quehanna facility.

Refractory material friction and wear characteristics, for high-temp seals and bearings, investigated by Battelle indicate: wear is greater on parts with interrupted surfaces such as slider bearings; it is less on continuous ring surfaces, and on ceramics and cermets with low thermal-stress-resistance and low thermal diffusivity.

PRODUCTION

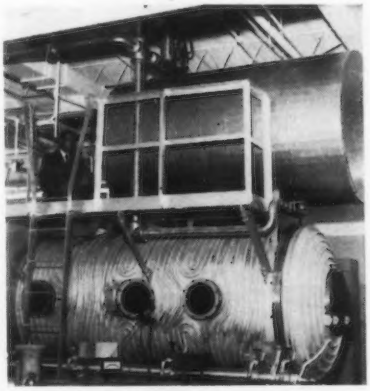
Uniform oxide dispersion in a metallic matrix can be effected routinely with existing equipment as a result of nuclear fuel element research in HTRE-3 at General Electric.

Vibratory deburring—developed by Lord Chemical and Equip Div. of Wheelabrator Corp. has increased production rates 8½ times.

Forming with electromagnetics at Convair-San Diego is being used for swaging of control-rod ends, coaxial cable, and for expansion of tubing. Process is reportedly applicable also to blanking, priming, embossing and drawing of metals.

Explosive forming technique at National Northern Div. American Potash & Chemical Corp. has produced J-93 engine-housing parts of Hastelloy and Multimet material. Sections were made of 0.020-in. sheet, to ±0.010-in. tolerance on a 43-in. diam.

Explosive welding studies at Stanford Research Institute open new possibilities for welding unusual materials previously difficult or impossible to weld. Low distortion, and absence of bead or fillet characterize the process.



ION ENGINES designed and produced by Rocketdyne will be tested in new vacuum tank at its Electric Propulsion Lab. Tank is 12 ft long, has 5 ft diam, accommodates 1/10 lb thrust engines.

Procurement

AEROSPACE DATA CAPSULE 3

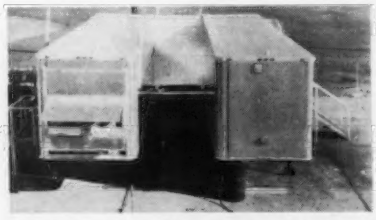
Business Moves

Reflectone Electronics, Inc., which is being acquired by Universal Match Corp., designs and manufactures advanced electronic and electromechanical systems which include trainers for: B-58, B-52, B-47 and Polaris submarine navigation. Firm is building a new research plant in Fort Lauderdale.

Hughes Aircraft Co. has opened its instrument calibration laboratory to private industry. Formerly reserved for use on Air Force equipment the lab was organized to perform volume calibration and maintenance of electronic instruments to be used for checkout of operational aircraft systems.

Rocketdyne has established a new Research and Engineering subdivision called Space Engines which will be responsible for the design and development of liquid propulsion systems and attitude controls for satellite and space vehicles.

Callery Chemical Co. has moved its Encino, Cal., laboratories to larger quarters to increase its capabilities for research in advanced chemical energy systems.



GRUMMAN AIRCRAFT ENGINEERING is delivering mobile pilot ready rooms to Navy. Trailerized facility consists of two trailers, one furnished as a dressing room, is connected by an enclosed walkway to the second trailer which is the briefing room.

Contracts

De Havilland Aircraft — $13,173,910 for production of Army's AC-1 Caribou transport.

Melpar, Inc. — $1,700,000 to build two flight trainers for Douglas Aircraft's A4D 2N weapon system.

Chance Vought Corp.—$2-million from NASA to develop fuel and LOX tanks for Saturn.

Aeronutronic Div., Ford Motor Co.—$5,361,619 to continue development of Shillelagh.

Westinghouse Electric Corp.—$7,300,000 for development and production of Typhon weapon system direction equipment from Navy.

General Electric Co.—$20-million for new MK 84, advanced Polaris fire control system.

General Precision, Inc. — $6-million from Air Force for flight and visual simulation systems.

Electronic Specialty Co. — $5-million for electrical and electronic equipment for the F-104 Starfighter.

Nuclear Development Corp. of America—$73,960 for development of methods of calculating performance of nuclear reactor shields for space application.

The Martin Co. — $100,000 study contract for RIFT Re-actor In-flight Test System.

Tracerlab, Inc.—$1,733,000 in prime R & D contracts places firm high in ranks of nuclear applications firms.

Western Electric Co.—$4,029,019 for production engineering services for the Nike Hercules system.

Huyck Systems Corp.—$3-million for a tactical ASW display and computer system to be used aboard Navy's S2F-3.

Grumman Aircraft Corp.—$38-million for additional production of carrier-based W2F-1 Hawkeye.

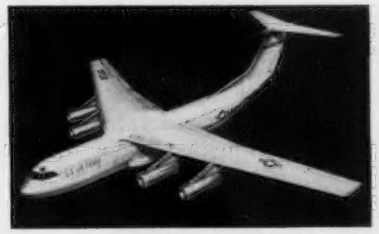
Facilities

Special Devices, Inc., is building a new ordnance facility in Newhall, Cal., which will include rocket motor test cells, environmental test lab, electronic instrumentation and static test building. Firm manufactures ignition and infrared systems, stage separation systems and other missile and space vehicle components.

North American Aviation, Inc., has completed its AeroSpace Laboratory in El Segundo, Cal., for testing of advanced manned aircraft and space systems. Lab includes an accoustical test facility, environmental test chamber and wind tunnel.

Systems Engineering Laboratories Inc. is a new Ft. Lauderdale, Fla., firm which will produce data systems for space applications.

United Technology Corp. has opened its new Research and Engineering Center and its Development and Test Center near Morgan Hill, Cal., for the production and testing of some of the largest solid propellant rocket motors in the world.



LOCKHEED AIRCRAFT CORP. has received $1-billion contract from Air Force to develop and build high-speed jet cargo and troop transport. More than 100 of the CX-1 will be built. Lockheed will subcontract more than 50 per cent of the job.

Only Weller MAGNASTAT® Soldering Irons offer all these features!

HALF THE WEIGHT OF UNCONTROLLED IRONS

2 SOLDERING TEMPERATURES WITH MODEL TC552

2 OR 3-WIRE CORDS ARE AVAILABLE FOR ALL MODELS

HEAT CONTROL IS IN THE TIP

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GREATER HEAT EFFICIENCY WITH LOWER WATTAGE

COOLEST HANDLE

Various tip types are also available—made of copper for fast heat transfer and premium iron plated for long life. Advanced cord connection locks securely, yet permits easy replacement. Rubber shock absorber prevents iron from sliding off bench.

3 models cover all electrical and production line requirements

Model TC552 - 55 watts **$9.00** list
Model TC602 - 60 watts **$10.00** list
Model TC1202 - 120 watts **$11.50** list

(prices shown are for irons with tip and 2-wire cord)

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Harrison Radio Corporation
225 Greenwich Street

Terminal-Hudson Corporation
236 West 17th Street

Paterson, New Jersey
Garden State Tool Supply, 76 River St.

Philadelphia, Pennsylvania
Almo Radio Co., 913 Arch Street

Philadelphia Electronics, Inc.
1211 Vine Street

Pittsburgh, Pennsylvania
Radio Parts Co., 6401 Penn Ave.

IN THE MIDWEST

Chicago, Illinois
Allied Radio Corporation
100 North Western Avenue

Newark Electronics Corporation
223 West Madison Street

Cincinnati, Ohio
United Radio, Inc., 1314 Vine St.

Dayton, Ohio
Srepco, Inc., 314 Leo Street

IN THE SOUTHWEST

Alamogordo, New Mexico
Radio Specialties Co., 209 Penn Ave.

Albuquerque, New Mexico
Radio Specialties Company, Inc.

Houston, Texas
Busacker Electronic Equipment Co.
1216 West Clay Street

IN THE WEST

Denver, Colorado
L. B. Walker Radio Co., 300 Bryant St.

Glendale, California
Claude Michael, Inc., 704 West Ivy St.

Grand Junction, Colorado
L. B. Walker Radio Company
537 North First Street

Inglewood, California
Newark Electronics Co., Inc.
4747 West Century Blvd.

Los Angeles, California
Garrett Supply Company
3844 South Santa Fe Avenue

Kierulff Electronics
820 West Olympic Blvd.

Radio Products Sales, Inc.
1501 South Hill St.

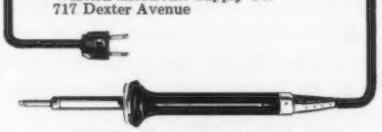
Phoenix, Arizona
Garrett Supply Company
2950 West Thomas Road

Pueblo, Colorado
L. B. Walker Radio Company
100 North Victoria

Salt Lake City, Utah
Strevell-Paterson Hardware Co.
1401 South Sixth—West

San Francisco, California
Sloss & Brittain, 100 Potrero Avenue

Seattle, Washington
Western Electronic Supply Co.
717 Dexter Avenue



Circle 10 on Inquiry Card

Market Planning

AEROSPACE DATA CAPSULE 4

Control Slump Seen

GUIDANCE AND CONTROL MARKET—MISSILES

Missile system control			
Research and Dev.	$ 24 million	$ 16 million	$ 15,000 million
Procurement	$211 "	$167 "	$145,000 "
Total	$235 million	$183 million	$160,000 million
Missile system guidance			
Research and Dev.	$146 million	$104 million	$ 97 million
Procurement	$394 "	$491 "	$506 "
Total	$540 million	$595 million	$603 million

This is how the market shapes up for missile guidance and control systems through 1965. The prospects in guidance are for increasing business. In controls the outlook is for a down swing. Market analysts give the reason for this downward projection as an anticipated decrease in the procurement of missiles which use expensive aerodynamic controls.

The outlook will be altered if Nike-Zues is ordered into production in numbers. The anti-missile missile uses both aerodynamic and thrust controls. A complete breakdown of funding on specific control and guidance systems can be obtained on request. Write: Market Research, Aircraft & Missiles, Chestnut & 56th Sts., Phila. 39, Pa.

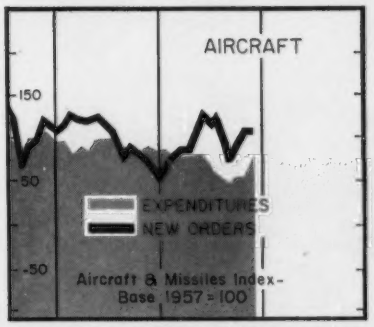
Where Curves Cross

Timetable for the resurgence of manned aerospace vehicles over missiles can be seen shaping up in General Electric's advance plans. GE estimates that $50 million was spent on manned space vehicles last year. By 1970 funding for manned vehicles will hit $1.75 billion in the military field alone. Space Sciences Lab of GE's Missile and Space Vehicle Department is gearing to capture a large portion of this business. The facility is organized under five major research groups: advanced aerodynamics, aerophysics, structures and dynamics, materials studies, and special projects. Forty one percent of MSVD's space work is related to nose cones. But work on space vehicles has moved steadily forward to account for thirty eight percent of MSVD sales. By 1965 GE looks for its volume to double at MSVD, with sixty five percent related to space vehicles.

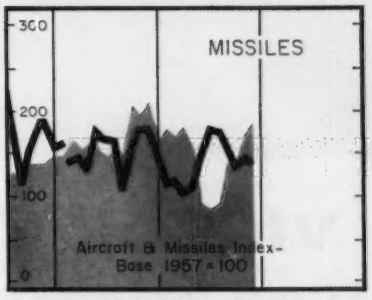
Budget Briefing

President Kennedy's fiscal 1962 defense funding request is $1.954 billion more than the $41.840 President Eisenhower requested. Actual 1962 spending is about $650,000,000 more. The balance goes to long range spending. President Kennedy wants an increased buildup of Polaris submarines, fixed base Minuteman ICBM, and stepped up "small-war" preparations. The President's plan calls for 29 Polaris submarines by the end of 1964 instead of 19, and acceleration of development of the 2,500-mile A-3 version. The Minuteman program would drop, for the time being, the plans to put these solid-fuel missiles on railroad trains, but would expand production for land-based sites. This would make available $220 million more than originally planned for Minuteman missiles. Two squadrons of liquid-fueled Titan ICBMs would be dropped. The Skybolt air-launched ballistic missile program would be stepped up $50 million. Two of the President's plans are expected to bring him to blows with Congress. He is cutting back the B-70 bomber program and dropping the nuclear plane project.

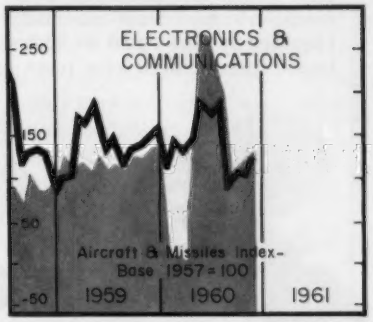
DEFENSE EXPENDITURES AND NEW ORDERS
3 Months' Moving Average Index



Aircraft includes air-frames, engines armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



Electronics and communications graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation airs, countermeasures, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

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Control gases safely and accurately to 10,000 psig.

Victor high pressure gas regulators are cleaned, assembled, tested and packaged under carefully controlled conditions to insure maximum product reliability. Cleaning is performed to Victor standard or to customer specifications in a room approved by industry and military agencies. Regulators shown here are typical of the available models covering a range of pressures to 10,000 psig. and capacities of 80,000 scfm. at —67° F. to +250° F. Write for Regulator Inquiry Form 361B and regulator bulletins.

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GAS-O-DOME REGULATORS

Bronze or stainless steel
Pilot operated—low torque
Inlet to 10,000 psig.
Outlet to 10,000 psig.
Flows to 250 scfm.
Panel Mounting

GD40, GD90, GD100, GD200 SERIES
GAS-O-DOME REGULATORS

Bronze or stainless steel
Remote or integral controlled
Inlet to 6,000 psig.
Outlet to 6,000 psig.
Flows to 80,000 scfm.
Panel mounting if desired.

LR SERIES LOADER REGULATORS
BPR SERIES BACK PRESSURE
REGULATORS

Bronze or stainless steel
Inlet to 10,000 psig.
Outlet to 10,000 psig.
Flows to 10 scfm.
Low operating torque:
40 inch lbs. at 7,000 psig.
60 inch lbs. at 10,000 psig.
Panel mounting.

GD60 AND GD80 SERIES
GAS-O-DOME REGULATORS

Bronze or stainless steel
Remote or integral controlled
Inlet to 10,000 psig.
Outlet to 10,000 psig.
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Management

AEROSPACE DATA CAPSULE 5

MANAGEMENT COOPERATION

ACF Industries and North American Aviation are cooperating on a nuclear rocket engine program.

Baird-Atomic, Inc., and Controls for Radiation, Inc., have formed a jointly-owned subsidiary, ChemTrac Corp., to manufacture radiochemicals.

Communication satellites, provided and launched by NASA, will have tracking and testing stations provided by England and France.

Hawker Siddeley Aviation and S.E.R.E.B. (Société pour l'Etude et la Réalisation d'Engins Balistiques) have agreed on French-English cooperation in questions regarding the technical and industrial aspects of space engineering, and to establish a common action policy.

PRETESTING MANAGEMENT

Hughes Aircraft Communications Div. pretests management plans for production by using a computer technique. One month's work task with alternate plans can be represented on computer in 15 min. Management can select best plan from computer results.

Similar techniques were demonstrated by RCA during a recent mass management game. The game, used techniques developed in RCA's forecasting of the 1960 presidential election.

MACHINE TOOL MODERNIZATION

President Kennedy has revealed how the modernization of machine tools in our production lines is a vital part of the Administration's "New Frontier." The president will propose to the Congress a new tax incentive for business to expand their normal investment in plant and equipment.

PAYMENT PROCEDURES REVISED

DOD Directive No. 7800.6 which provided for withholding 20 per cent of costs incurred by contractors on cost-plus-fee contracts until contract fulfillment has been rescinded by Deputy Secretary of Defense Roswell Gilpatric.

EFFECTIVE COST CUTTING

A recent Air Force survey of 70 firms shows that 28 firms have brought about identifiable cost reductions totaling $570-million by improving purchasing and procurement, value engineering, reorganization and consolidation, modernization and improved methods.

MANAGEMENT QUOTES

Rep. Edgar W. Hiestand (R-Cal.) called President Kennedy's decision to cut back the B-70 program a "tragic blow to the national security of the United States."

R. L. Johnson, chief engr., Douglas Aircraft Co., before House Committee on Science and Astronautics; "The potential of nuclear spaceships so far exceeds that of any other presently feasible means of space travel that development should be vigorously pursued at once."

J. R. Dempsey, manager, Convair-Astronautics; before House Committee on Science and Astronautics; "Operational nuclear space vehicles can perhaps be available in less than 75 months from such a go-ahead date; for example, by 1967-1968."

Krafft A. Ehricke, world renowned rocket scientist, urged today that the U. S. step up research on nuclear powered spacecraft in preparation for the approaching "super-energy" needs of deep interplanetary travel. "Nuclear power is a must. . . . We know now that chemical rocket fuel will be impractical for manned space travel beyond the moon."

S. K. Hoffman, president, Rocketdyne, before House Committee on Science and Astronautics; ". . . boosters (liquid) can be reused for 50 or more space launchings for essentially the cost of propellant, approximately five cents a pound."

Panelists discussing "Commercial and Economic Aspects of Space Flight" at the Fourth Annual National Missile/Space Conference, were asked the following question:

QUESTION: Do you think a relaxation in the cold war would result in a frantic dumping of funds by the United States Government into the space program; and should this accelerate space work?

Dr. Arthur R. Kantrowitz, vice president, Avco Corp.; "The question . . . seems to be so far from today's realities as to be impossible of a sensible answer."

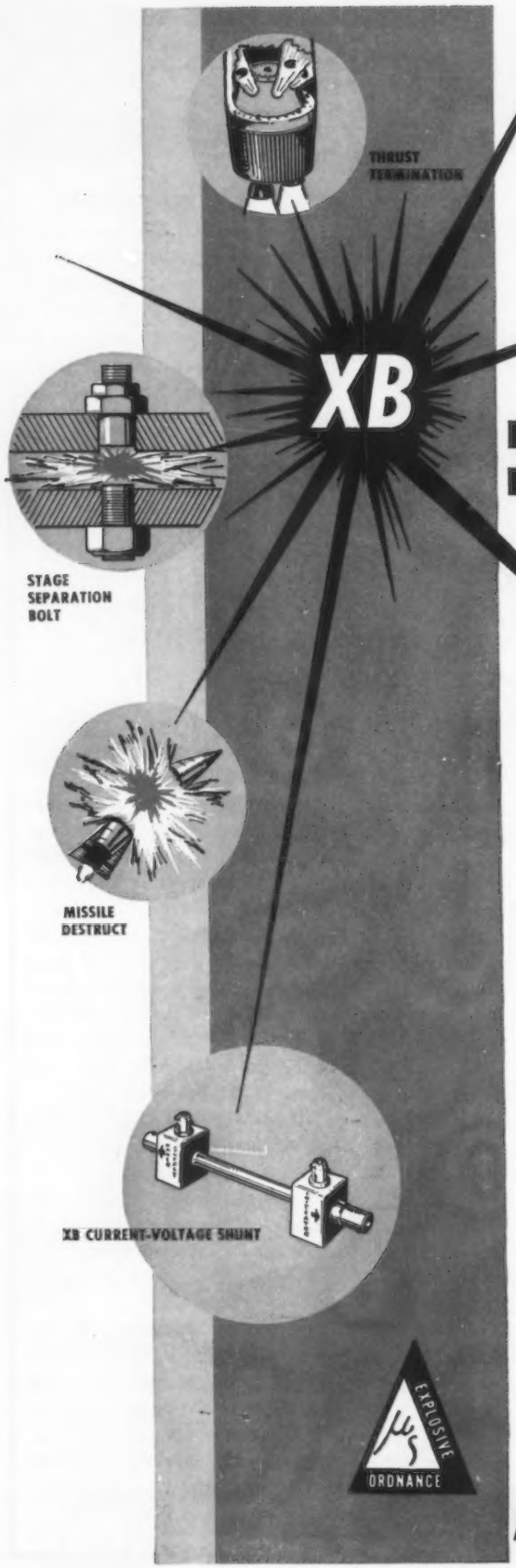
Kurt R. Stehling, NASA; "As long as space is a geopolitical status symbol . . . it will be part of a cold war; but, if there is such competition, it will go on endlessly, with probably ever-increasing vigor, until someone collapses economically."

Alfred M. Mayo, NASA; "Possibly, we have to consider the alternative . . . unless there were . . . very vigorous leadership to compensate for the drop in defense motivation . . . we would probably stand in equally great danger of going into a slump."

Dr. Ernest Stuhlinger, NASA; ". . . we must not forget that neither the Russian or American space programs today would be as far as they are without this competition."

Martin M. Decker, president, The Decker Corp.; ". . . is space a place or is it a race?"

←—Circle 11 on Inquiry Card



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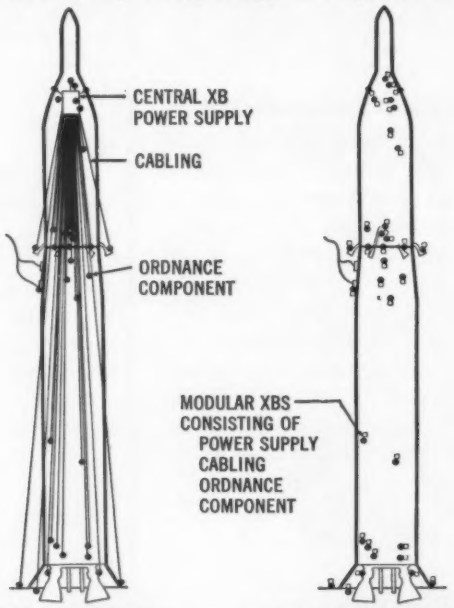
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More Electrical Power For Space Vehicles

AEC's SNAP units pack isotope- and reactor-type generators; SNAP 10 reactor will develop 300 w for a weight of 620 lb; Abundant electricity promised for power-starved satellites

by Lt. Col. G. M. Anderson, USAF
Chief of Systems for Nuclear Auxiliary Power, Missile Projects Branch, AEC.

A broad spectrum of instrumented-satellite missions is now planned to give man a footing in space. The key to preforming most of these missions is the electrical power on-board satellites.

For the foreseeable future, nuclear energy promises to be the most likely source for electrical power for such purposes.

Presently, we have a few thousand pounds of useful payload in orbit, with an on-board transmitting power on the order of 100 watts. Most of these small powerplants use photovoltaic converters (solar cells).

Typical Example — Explorer VI, launched in August, 1959, had a power unit of about 35 lb; the satellite weighed 142 lb. Although it failed to produce the full-rated power of 25 watts, this figure represents a power output of 0.7 watts/lb of powerplant weight.

Consider also the Midas II satellite launched in May, 1960, which weighed 5000 lb. Ascribing the same weight fraction to the powerplant and the same power output per lb, a power level of 900 watts would be required to accomplish a limited scientific mission similar to that of Explorer VI.

Construction of this large solar unit would indeed be a difficult engineering task. Based on extrapolations of previous designs, it would have four 100-ft^2 panels and a total of about 290,000 solar cells. The panels would have to be remotely erected and oriented. Cost of such a unit would probably be well over $1 million, or roughly $1000 per electrical watt.

The 800 ft^2 of solar cells would be subjected to erosion by meteoric dust, over a year's time, as well as high energy electron and proton fluxes. Even with 60 mil cover glass-protection for the cells, the power is expected to decrease 25 to 50 per cent in a few months. Reliability of a multi-million-dollar vehicle system under these conditions is largely a guess.

Solar power units, however, have served their purpose well. The simplicity of such units up to low-power levels of possibly 100 watts is obvious to the vehicle designer. Above this, however, the designer is faced with complex folded arrays that must be constantly oriented (and which use power), environmental hazards, and oriented antenna systems.

Advantages—Transistorized circuitry has become a necessity to keep weight and power requirements low. Large, reliable communication systems, based on the transistorized circuits will also have limited life unless shielded from the radiation of space. By way of contrast, then, the main advantages of nuclear-power generators for use in space are:

- Relative imperviousness to the hazards of space environment.
- Kilowatt sizes can be integrated into present-day vehicles such as the Atlas-Agena. Several kilowatts could be employed in a Midas type mission. Tens of kilowatts will be available for Centaur.
- Orientation of large surfaces is unnecessary. Need for high-gain antenna systems can be reduced because of adequate on-board power.
- Solar transients from day to night have no effect on nuclear units.

continued on next page

Beryllium reflector of SNAP 2 system separates from core for shutdown and handling

- Nuclear generators are capable of constant full-power operations; hence batteries can be eliminated.
- Weight will be about 50 lb/kw in 20 to 30-kw sizes. Approximately 5 lb/kw will take care of shielding.
- Weight for future megawatt-size units is expected to be less than 10 lb/kw.
- Nuclear units are inherently rugged.
- A basic cost of about $300 per watt is achievable in kilowatt sizes.

Present AEC program to produce nuclear-electric power, referred to as Systems for Nuclear Auxiliary Power (SNAP) grew from Air Force studies of early 1950's. These studies concluded that power would be required in the kilowatt ranges and that nuclear reactors would be the only feasible method.

Objectives—Specific objectives of SNAP program have been to demonstrate basic capability in: (1) Low-power isotope-thermoelectric and thermionic generators; (2) Compact reactor-thermoelectric generators; (3) Compact reactor-turbo-electric generators; (4) Compact reactor-thermionic generators.

At present, power spread is from a few watts in the isotope generators to tens of kilowatts in the reactor-powered units.

Let us examine now some of the basic features of these generators.

SNAP 3 — This "atomic battery" which was presented to President Eisenhower in January 1959, is representative of a family of very small generators which can use a variety of radioisotopes as heat sources to power thermo-piles (A&M January 1960, p. 28). Isotope fuels under active consideration are the alpha emitters such as Curium-242 with a half-life of 162 days, and Plutonium 238 with a half-life of 80 years. SNAP 3 used Polonium 210, produced three and a half watts, and weighed four lb.

Our latest model uses Curium-242 and thermionic conversion, and will produce seven watts in a weight of just nine oz. Units of this type will find applications in deep-space probes, soft lunar-landings, etc. Terrestrial and deep-sea applications have also resulted from this effort.

SNAP 2—This system will demonstrate operational capability of a reactor-powered turbo-electric system. Energy is produced by the fissioning of Uranium-235.

A liquid metal (NaK-78) is circulated through both the reactor core and the mercury boiler superheater by a rotating permanent-magnet pump. In the boiler superheater the reactor heat is transferred from the primary reactor coolant to the mercury working fluid of the Rankine power-conversion cycle. Reactor heat converts liquid mercury into superheated vapor which is expanded through a turbine. The resulting mechanical power output of the turbine is converted to electrical power by the alternator. Mercury vapor exhaust from the turbine is condensed in the radiator-condenser, which is part of the outer skin of the spacecraft. The mercury condensate is returned to the boiler by a boiler feed-pump.

Minimum Weight—SNAP 2 reactor uses a homogeneous fuel-moderator of zirconium hydride

SNAP EXPERIMENTAL REACTOR (SER) produces 50 kw thermal power and 1200°F exit coolant temperature. Reactor core is in cylindrical container.

SNAP 10A SYSTEM may be the earliest application of nuclear electric power in spacecraft; flight demonstration of this system may take place in 1962-63 period.

containing Uranium-235. This moderating material has a hydrogen density equivalent to cold water, however, it has the feature of retaining this density at high temperature while water does not. This fact permits the construction of compact SNAP type reactors. For minimum weight, the reactor is reflected by beryllium and is controlled by varying the reflector thickness through rotation of two semi-cylindrical, beryllium drums. The core is composed of a bundle of cylindrical, fuel-moderator elements. Beryllium slugs, located at both ends of the fuel elements, form the reactor and reflector.

Each fuel element is clad in a thin-wall steel tube to exclude the liquid metal coolant. Steel cladding tubes are internally-coated to minimize hydrogen loss from fuel-moderator material. The core is contained in an approximate 9-in.-diam by 12-in.-long vessel, with two in. of beryllium as a radial reflector outside the vessel.

Separable Reflector — The reflector is completely separable from core for safe shutdown and handling. The 50 kw of heat-power is removed by flow of liquid metal through the core between the fuel elements. Coolant enters the core at 1000°F and leaves at 1200°F.

First reactor in the SNAP 2 program was a critical assembly composed of compressed powder blocks. This assembly verified the criticality calculations for the fuel material, went critical in October, 1957, and has been in use over two years. Simultaneously with this critical experiment, design of the first power reactor, the SNAP Experimental Reactor (SER), was carried out. The SER operating conditions were 50 kw thermal power and 1200°F exit coolant - temperature. The SER core, tank, reflector, and necessary hardware, weigh just 250 lb. The reactor went critical in September, 1959. By April, 1960, it had completed a continuous run of 1000 hr at full design-power and temperature. After more than a full year of successful operation, reactor was shut down on Nov. 18; more than 50 per cent of that year was spent at full power.

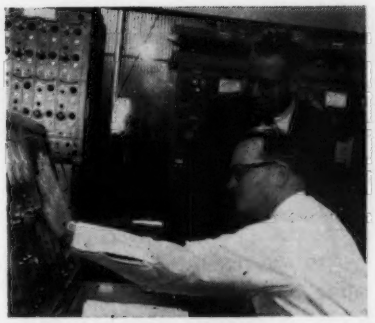
Startup Scheduled—The second SNAP power reactor is called the SNAP Development Reactor (SDR). It is scheduled for startup in June, 1961. The results of SER operations led to changes in fuel composition, number and size of fuel rods, and reflector design—all of which permitted a reduction in weight from 250 to 200 lb. A similar SNAP reactor at ten times the power is not much larger. The SDR will operate the first complete version of the power conversion system. All the components in this series of tests will be of flight configuration.

All the rotating components of the power-conversion system are mounted on a single shaft. This makes up the combined rotating unit (CRU). The shaft rotates at 40,000 rpm and is supported by liquid - mercury - lubricated journal and thrust bearings. The CRU is the only moving part in the entire power-conversion system.

Sealed Housing—Completed assembly is enclosed within a hermetically-sealed housing which prevents loss of mercury during the system life. The CRU has so far been tested for a continuous run of 20 days. A similar system was tested for 104 days at lower powers with no indication of deterioration or damage. These tests show that long-life operation of the system is attainable.

The mercury boiler-superheater is a shell-and-tube, counter-flow, once-through boiler with NaK in the outer shell and mercury in the central tubes. Helical-boiler configuration provide an artificial gravity by centrifugal acceleration and improves heat-transfer characteristics.

Mercury condensation takes place at 600°F and six psia within a number of small-diam parallel tubes. These are attached to the aluminum skin which, radiates the waste heat to space. The total area necessary to radiate 50 kw at 600°F is about 110 ft.



PUSHING "SCRAM" BUTTON by author Lt. Col. Anderson, marks successful completion of ground run for SER. Watching milestone is R. R. Eggleston of Atomics International Div., North American Aviation, which developed SER for Atomic Energy Commission.

Weight Breakdown — SNAP 2 system approximate weight (lb) breakdown is:

Reactor	200
Boiler	100
CRU unit	50
Radiator w/liquid inventory	150
Controls	20
Structure	50
Piping	30
Total	600

First flight tests of SNAP 2 system are scheduled for early 1964.

SNAP 8—This powerplant is a larger version of SNAP 2. SNAP 8 will produce 30 kw with one power-conversion unit, and 60 kw with two power-conversion units coupled to the same reactor. The reactor will utilize the same fuel material as SNAP 2 but the smaller rods will provide for the higher power of 600 thermal kw. Coolant outlet temperature from reactor is 1350°F. Four control drums are needed to provide for the greater control requirements as compared to two in SNAP 2. At 30 kw output, SNAP 8 will weigh about 1500 lb, and at 60 kw it will weigh about 2700 lb.

Power-conversion system, which is being developed by NASA, will use mercury Rankine cycle as in SNAP 2. Generally higher operating temperatures and pressures will

SNAP 8 will be used for long-lived communications from lunar and interplanetary missions

be needed. Power-conversion subsystem will retain the combined rotating unit concept developed for SNAP 2; however, the NaK pressure-pump will be separately motor-driven for higher efficiency to obtain the higher NaK pressure required at the tenfold increase in coolant circulation rate.

NASA has announced that SNAP 8 will be used for long-range, long-lived communications from lunar and interplanetary missions, also for providing power in early electric-propulsion devices.

First SNAP 8 experimental reactor will go critical in early 1962. Flight tests will probably take place several years later.

SNAP 10 — Another reactor power-system currently under development is SNAP 10. This system will demonstrate operational capability of a reactor-powered thermoelectric system. The fuel is essentially the same as in SNAP 2 but plates are used instead of rods and reactor is conduction-cooled. Heat is conducted from fuel plates in reactor core through the beryllium reflector, and through the thermoelectric converter, and finally to the fins which radiate it to space.

The SNAP 10 system will produce 300 watts at a system weight of 620 lb. Adequate separation distance must be provided to permit light-weight shielding of radiator fins.

After startup, SNAP 10 will operate without the aid of active control systems, and will have no moving parts. System control will be provided by the strong negative temperature coefficient of reactivity inherent in this type of system. System life is estimated to be several years.

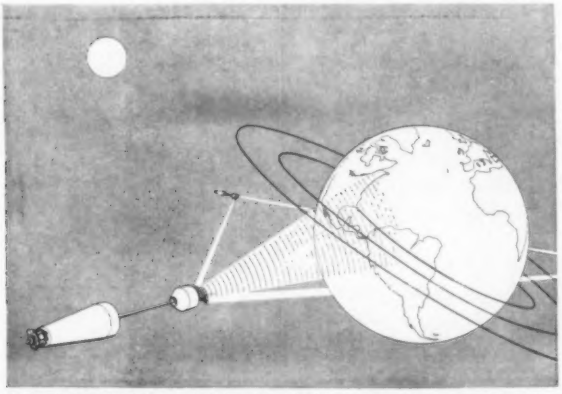
Startup is greatly simplified because there are no moving parts. System will be pre-calibrated so it can be taken to criticality by merely moving two reactor halves together and allowing system to seek its equilibrium temperatures. First SNAP 10 test-reactor went critical in the Fall of 1960.

More Flexibility — Another more flexibile version of the SNAP 10 concept (SNAP 10-A) uses the higher-powered SNAP 2 reactor and the thermoelectric converter materials developed in SNAP 10. Main difference is that it provides for growth to higher power-levels by separating thermoelectric converter from reactor.

By placing the converter in the protective shadow of the reactor shield, a material savings in weight is achievable as well as flexibility in power output. Power up to one or two kw electric is feasible. In this device, reactor heat is transferred to converter by a convective NaK loop circulated by a small electro-magnetic pump. Such a system may be the earliest application of nuclear electric power in spacecraft; flight demonstration of this system may take place in the 1962-63 period.

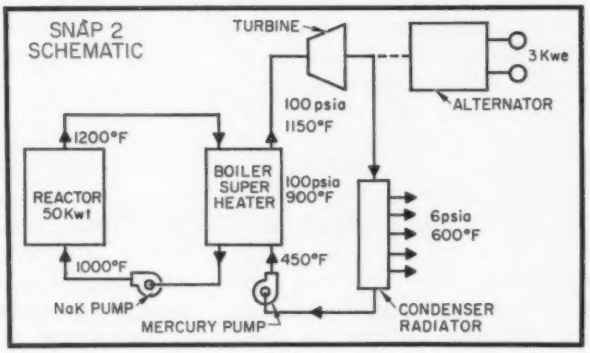
Role of SNAP in Overall Program—The practical use of space for mankind was aptly illustrated by Tiros satellite, launched in April, 1960. With 20 watts of power, this compact unit produced 300 weather pictures per day and taxed our ability to assimilate them. Long-range weather surveillance of this kind could be of great value to the world in preventing storm damage, assisting crop growers, etc.

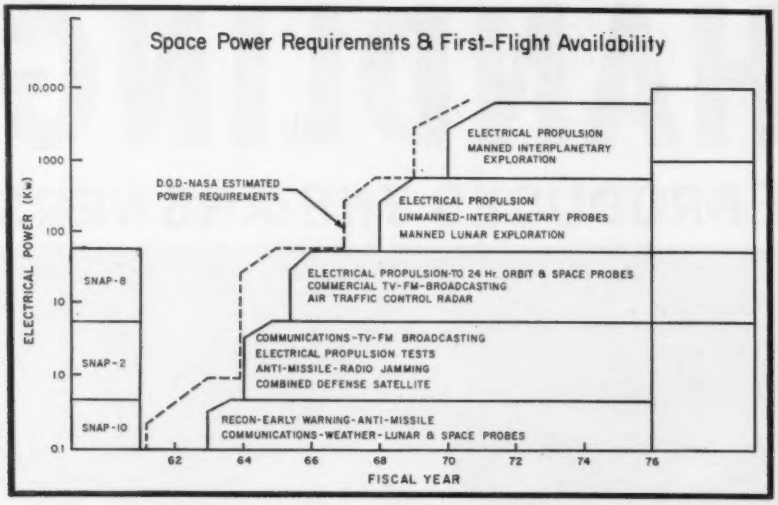
Consider, however, a more difficult application that could be made

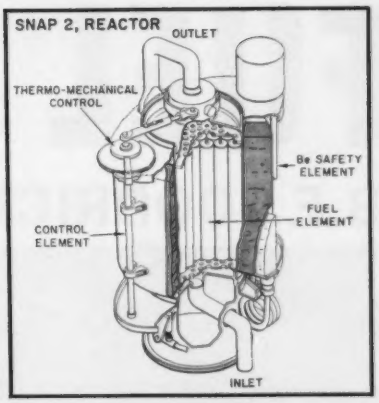


WORLD-WIDE TELEVISION would be possible by placing three equatorial satellites, powered by SNAP systems, into 22,600-mi high orbit.

SNAP 2 SYSTEM will demonstrate operational capability of a reactor-powered turbo-electric unit. Energy is produced by the fissioning of Uranium-235.







SNAP 2 will demonstrate operational capability of a reactor-powered turbo-electric system.

a reality with enough power—that of commercial world-wide television, utilizing our present TV sets. Consider the importance to world understanding if we could observe the Soviet's newscast and they, ours—first hand.

A SNAP power unit could be installed in a 24-hr Earth satellite for this purpose. Such a satellite at an altitude of 22,600 miles in the equatorial plane would be stationary in full view of the United States. Three such satellites would have a combined field of view covering the entire earth (A&M March 1960, p. 26).

Possible Combinations—If the three-kw SNAP 2 the 30 or 60-kw versions of SNAP 8 were combined with the Atlas-Agena B or the Atlas-Centaur spacecrafts in 24-hr orbits, then up to 10 or 15 video channels could be telecast. These systems would permit use of present home television receivers with the addition of just a simple UHF converter and six-ft^2 mesh-type antenna directed toward the stationary satellite. These minor changes to a home television set would cost the citizen about $50.

Under these conditions SNAP 2 is capable of furnishing enough power for one or two channels over the entire United States. SNAP 8 at 30 kw could furnish five to 10 channels over the entire United States or one or two channels over the entire hemisphere. This capability would be approximately doubled if the 60-kw version of SNAP 8 were put into use.

Economy of System—The economy of such a system is most attractive. Consider, for example, a 4500-lb Agena-B spacecraft in a 300-mi orbit. By powering a 300-lb electric propulsion system with a 1500-lb, 30-kw SNAP 8, about three weeks would be required to place the entire vehicle—power plant and all—in the desired stationary orbit. Probably 1500 of the 2700 lb in orbit would be available for the communication system payload.

Possibly $30 to 50-million would cover the cost of the entire International Television Broadcasting (ITVB) system, including the cost of the nuclear power-plants and the three spacecraft for global coverage. Assuming that the satellite located over the United States would power five to 10 channels simultaneously for a year, the cost per channel-hour would be about $300.

Current transcontinental broadcast costs about $60,000 per channel-hour. Even further reductions in the cost of a channel-hour would be realized when the Atlas-Centaur system becomes available, for the ITVB system will then have at its disposal 60 kw and a 2000-lb payload for the communications equipment.

Here is a truly remarkable application of nuclear power: not only will it enable us to enlarge our understanding of other peoples, but, also it will dramatically reduce the cost of television, our most popular medium of communication.

Future Power - Requirements—Eventually even the SNAP 8 will not supply enough power for some of the missions projected for the giant Saturn and Nova Boosters.

To meet these and other future needs for higher-power systems, work is being done today to develop new types of nuclear-reactor systems. One of the most promising areas is in direct thermionic conversion of reactor heat to electricity. In this method the reactor fuel-rods will operate around 3500°F, at which temperature the fuel-converter assemblies will emit electrons at very high power density. This method, although in its infancy today, may one day have profound implications also for the entire power industry.

✦

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FUEL HANDLING

B.F.GOODRICH PRODUCES THE ANSWERS

SURGE BOOTS—absorb hydraulic shock.

FLEXIBLE CONNECTORS—for internal fuel lines.

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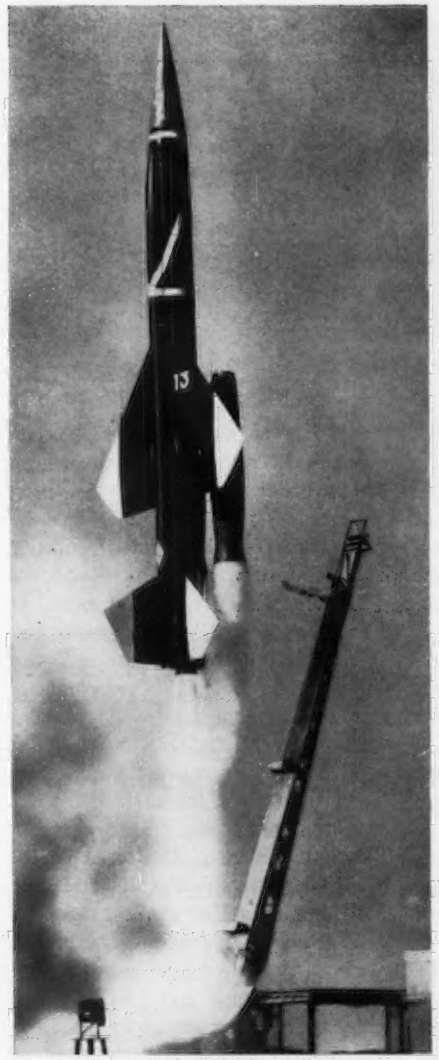
B.F.Goodrich designs and produces special products for a wide range of fueling requirements—surge boots, flexible fuel line connectors, fuel cells, hose, vapor barriers, and others for aircraft...motor cases, insulator liners, and solid propellants for rockets and missiles. For help in *your* applications check *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept., AM-5, Akron, Ohio.*

PRESSURE SWITCHES—BFG switches actuated by precision, Omega-design bellows perform many critical functions on jet engines such as indicating adequate fuel pressure, actuating afterburner igniters and unlocking nozzle area controls.

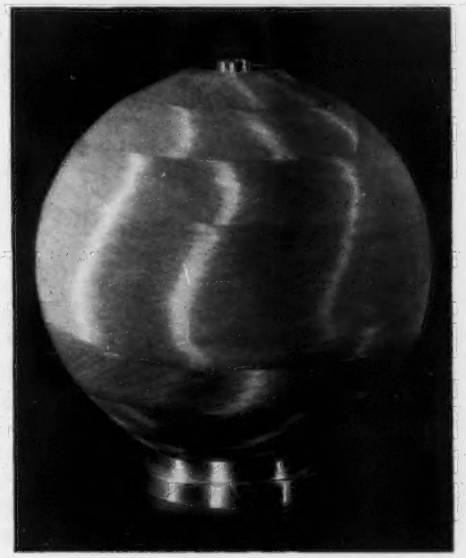
FOR UNUSUAL REQUIREMENTS



EXPULSION DIAPHRAGM—BFG supplies a special flexible diaphragm mounted in the fuel cavity of the Bomarc supersonic area defense missile. Diaphragm expels hydrocarbon fuels under pressure to external ram-jet engines.

WEIGHT-SAVING FLEXIBLE FUEL CELLS—This T-38 twin-jet trainer, made by Northrop, is one of many current aircraft using BFG fuel cells. Constructed with special fuel-resistant compounds, these cells are strong and lightweight. BFG fuel cell manufacturing is backed by complete development and test facilities.

SOLID-FUELED ROCKET MOTOR CASES—BFG offers complete capability in filament-wound rocket motor cases—also insulators. These glass fiber reinforced plastic structures are lightweight, strong, and are produced in many sizes and configurations.



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Nuclear Ramjet Propulsion . . . Problems and Progress

Tory II-A feasibility reactor now in operation, Flight-type reactor scheduled for ground tests in 1962, Aggressive program could lead to SLAM flight in 1965

by John P. Kushnerick

Optimism is rising to high tide in the Pluto nuclear ramjet program. Under joint AEC-Air Force direction the proof-of-principle ramjet reactor went critical in a successful first test in January. This reactor is known as Tory II-A. In 1962 a Tory II-C reactor will be fired up to test some flight-type hardware. And by 1965 a Pluto program powerplant could be airborne in SLAM (Supersonic Low Altitude Missile), or a similar nuclear ramjet missile. As envisioned ramjet could speed round the world at Mach 3 only 500 ft above the ground. It would be virtually immune to intercept.

Management Lessons — Air Force has not yet announced an official target date for flight. And SLAM is not yet an official weapon system. But it can be assumed that some management lessons were learned from the soon-to-be-terminated Aircraft Nuclear Propulsion Program. After a 15 year incubation period that ran the tab to near $1 billion this promising program ended in an abortion. Lack of realistic requirements, objectives, and goals plagued its development for years. In his fiscal 1962 budget President Kennedy called for a complete halt in the program. The predominantly Democratic Congress is not likely to argue the point.

This kind of lightning is not likely to strike Air Force twice. The nuclear ramjet program will get real, and probably accelerated test dates for flight hardware. And a requirement and development cycle for a SLAM-type missile will probably firm up soon.

Project Pluto—About $65 million has been charged to Project Pluto. Another $15 to 20 million could keep tests on schedule through the Tory II-C experiment with flight-type reactor control system and reflector in 1962.

Pluto got its start in 1956 as an AEC experimental program. The object was to develop technology, and to design, build, and test experimental reactors that could demonstrate the feasibility of nuclear propulsion for ramjets. Reactor work was put under the direction of AEC's Lawrence Radiation Lab (LRL) at Livermore, Calif. Atomics International gives assistance on materials studies. Marquardt Corp., under Air Force contract, engineering assistance for non-nuclear components.

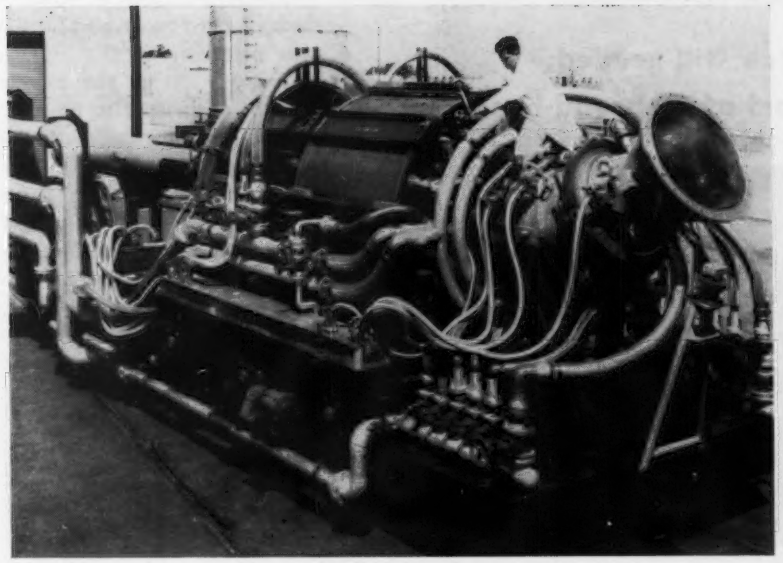
Pluto work encompasses materials research, neutronics research, reactor experiments, and propulsion-system design. Chief problem in bringing the nuclear ramjet to fruition has been finding materials that can withstand the high temperature radiation environment. Next problem is to find fabrication techniques for these materials.

The Tory Reactor—To verify the materials, neutronics, and reactor data, Tory-II was built. It is a moderated, homogeneous reactor. Beryllium oxide serves as the moderating material. Core elements are made from a newly developed ceramic.

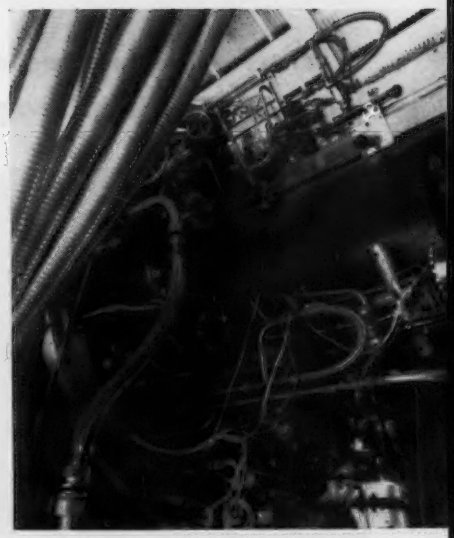
Although none of the hardware now on Tory is intended to fly, the reactor design was guided by ramjet requirements. The technologies will lead directly to a flight reactor through Tory II-C studies.

Design Influences—There are several requirements created by ramjet flight that pretty well narrow the basic reactor design to the Tory configuration. The minimum thrust to keep a ramjet airborne imposes a corresponding minimum temperature in the reactor. This minimum temperature is actually quite high when evaluated against current materials technology. The first ramjet-reactor requirement then is to attain the highest possible temperature within a realistic state-of-the-art projection for materials technology.

Thrust coefficient in a ramjet peaks at a flight speed of Mach 3. This sets the operational regime. It



TORY II-A nuclear ramjet experimental reactor went critical in successful first test in January at Nevada Test Site. AEC reactor is mounted on flat bed car and can be moved by locomotive.



CONTROL VANES and plumbing complex can be seen in Tory II-A close up. Marquardt is assisting AEC on non-nuclear components.

also sets the second reactor requirement. The reactor must be designed to stand high pressure across its face. At sea level, the stagnation point would be about 550 psi for Mach 3 flight. When weight, limitations, temperature requirements, and the nuclear environment are combined, some strict material requirements become obvious at this pressure.

The third reactor design factor is set by the amount of fuel that can be carried economically in a ramjet missile. This narrows the choice between a "fast" (unmoderated) or a "moderated" reactor. For a reasonable size missile the economics of using a fast reactor are staggering. The choice is obviously the moderated reactor. Selection of moderator material is almost immediately narrowed to BeO for the present. And there are not a great many prospects for the future.

Next comes the selection of a homogeneous or heterogeneous reactor. In the heterogeneous design the reactor fuel and the moderator are separated. The fuel must be protected from contact with the airstream by "canning" it in a high-temperature ceramic. This requires a material research program that could lead to many complications. In the homogeneous design the fuel is mixed with the moderator material. The same substance effects the heat transfer and moderation. This design presents less complications. The core of the reactor would be cylindrical with a length to diameter ratio of about 1 to 1. The cylinder would be drilled with small holes (length-to-diameter ratio of about 200) to effect airstream passage. About half the area of the cylinder face would be open area as a result of the drilling in a flight reactor.

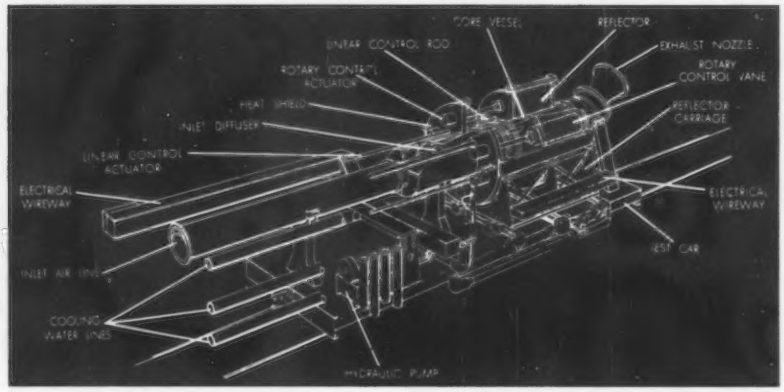
So it is not difficult to see how the Tory reactor took its present design configuration—a homogeneous reactor, moderated by beryllium oxide.

Mechanical Design—But all is not roses with this design. There are severe mechanical problems which arise because of the stresses on such a reactor in flight. They are primarily three: (1) Severe pressure drop across the reactor; (2) Thermal shocks which arise from transferring the heat directly by passing the airstream over the fuel; (3) Gust loadings which arise from Mach 3 flight at low altitude.

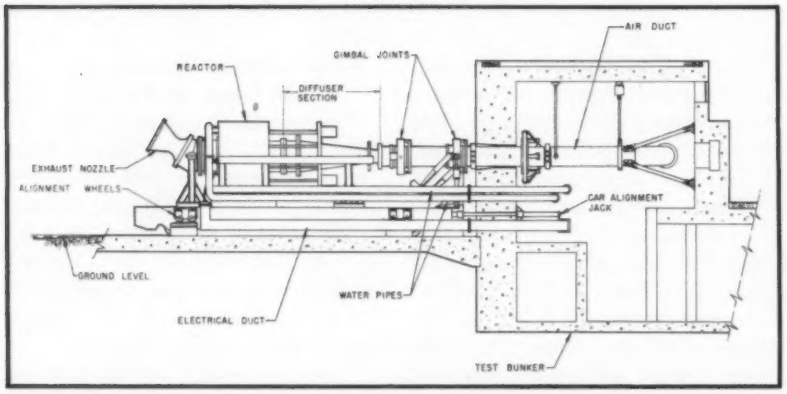
What Needs to Be Done—Dr. Theodore Merkle, Associate Director of LRL sums up major R&D areas that must be explored to actually produce a flyable nuclear ramjet engine as follows:

- High - temperature ceramic materials must be developed to high reliability. . . with respect to mechanical properties.
- Techniques for distributing the fuel in proper amounts in such materials have to be evolved. These techniques must provide that the material will not leak at high temperature. It would be nice if they did not leak fission fragments either.
- These materials must resist chemical attack so that the passage of air across the walls does not unduly limit the life of the reactor.
- Ingenious mechanical design features must be evolved.
- Nuclear physics of the "hot moderator" systems must be explored in great detail.
- Novel control systems compatible with flight must be developed.
- Economical fabrication, in-

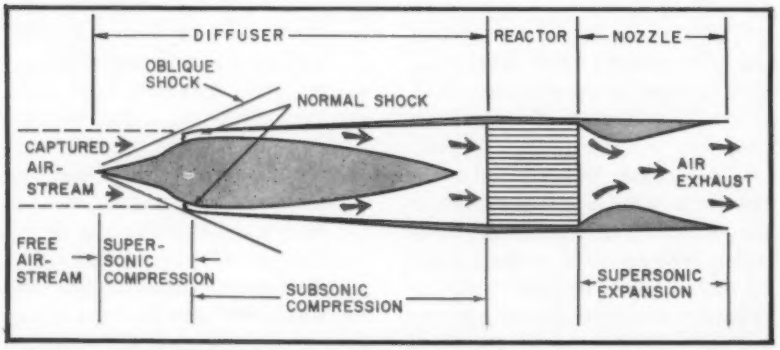
Extensive material research still needed; Vehicle subsystems are part of AF broad-base R&D



REACTOR DETAILS can be seen clearly in this schematic. Simulated ramjet air supply will be supplied at pressures up to 100,000 psi. Exhaust nozzle tilts upward at 38 deg.



TEST BUNKER contains the connections for air, water, and electrical supply necessary for Tory II-A ground runup. Tunnel 1000 ft long connects bunker and remote blockhouse.



NUCLEAR RAMJET has only three basic elements: diffuser, reactor, nozzle. The design of the inlet spike is important in slowing the inlet airstream to optimum speed. This can be accomplished by creating the proper shock pattern at the spike.

spection, and product-control methods must be devised for the new materials.

- Every item in the missile must be engineered to be compatible with the radiation environment.

SLAM Studies—Certain items in the nuclear ramjet have a lead time as long as the powerplant development. These are not going unattended to. Chance Vought Corp. is exploring the navigation and terrain avoidance systems. Navigation will probably be inertial. Terrain avoidance could be a combination of doppler radars and advanced map-matching. Much of the overall R&D work has a broad base and can be applied to other weapon systems.

Chance Vought was also recently invited to negotiate a new contract with Air Force as a result of their demonstrated technical competence in the nuclear ramjet field. If the contract materializes it will be to supply aerothermodynamic information to LRL and Marquardt for use in design and development of a Pluto nuclear ramjet.

Three companies were involved in an original study on the overall nuclear ramjet vehicle. They were Chance Vought, North American and Convair. The Chance Vought proposal looked best to Air Force at the time, and it was this company that originated the designation SLAM. But Air Force accepted the study without follow-on funding. Chance Vought's technical competency however was established, and the missile got an unofficial name. Most of the ramjet funding is now under SDR-11 (Systems Development Requirement).

Some new thinking in structures and aerodynamics has been generated in the ramjet program. Most notable is the possibility of using wingless vehicles. At Mach 2 to 5 conical shapes are said to have tolerable lift/drag ratios.

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Who Killed ANP?

Pseudo-scientific advice given to President on nuclear aircraft; DOD established design criteria then shot holes in project; Continuous airborne alert natural application for ANP

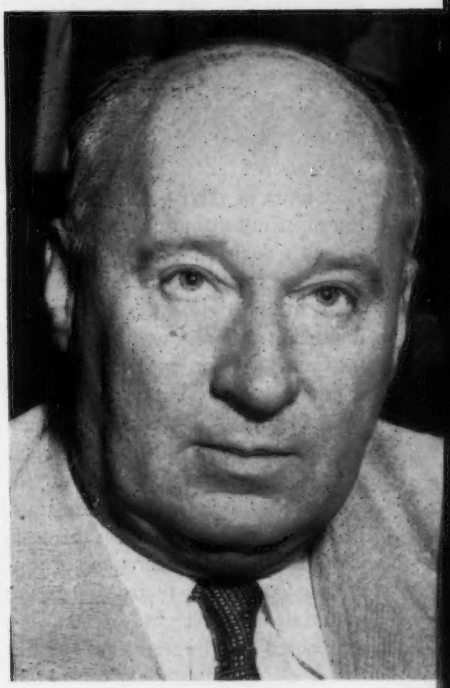
by Congressman Melvin Price, (Dem.—Illinois)

It is extremely unfortunate that the Aircraft Nuclear Propulsion (ANP) project has been cancelled. Nuclear propelled aircraft are important to the nation's future, I therefore believe we will some day develop such aircraft despite this latest executive decision. The decision just injects an indefinite delay that will cost us a great deal in money, and prestige.

Decision Inputs—I admire the President for his ability to make forthright decisions, although I question his decision relative to the nuclear aircraft programs. The previous administration, while pretending to support the ANP program, held back any real progress by their indecision. The Kennedy decision was in error because of incorrect advice provided by his scientific and defense advisers. The same people who have been assembling the information for decisions on ANP provided the input again. Based on my long acquaintance with their behind-the-scenes operations, it's no great surprise to me that again we have an adverse decision. This situation was brought forcefully to the forefront during the Joint Committee's executive hearings on the ANP program early in March. At our hearings we asked the Defense Department and the Atomic Energy Commission to tell us about the technical data and other considerations which supported new criteria which was formulated for the ANP project. We also asked whether, in the development of the latest criteria, the officials in the Joint AEC-Air Force Office responsible for the technical direction of the project, and the contractors responsible for developing the nuclear designs had been consulted.

Unfortunately, we couldn't get adequate answers to our questions. We did find out, though, that certain criteria recently set down by the Defense Department was in direct conflict with the testimony of experts responsible for the technical program. We also found out that the Defense Department did not even consult the experts responsible for the direction of the program and for the development of the designs. It was quite apparent from the hearing that the members of the new Administration in the Defense Department relied solely on the advice and recommendations of the same people in the Defense Department who have been against the project for years.

Pseudo-Scientific Advisers—What little testimony we could get from these people again confirmed the fact that they were not familiar with the technical developments in the program and had not even attempted to obtain first-hand information concerning the facts of our aircraft nuclear propulsion program. It was most discouraging to again come up against government career personnel whose actions for years have been—and are—the shuffling and assembly of the same papers



Congressman Price
"career paper-shufflers"

NX-2 had multi-mach growth potential, But this was never sold to top decision makers

and representing the information they contain as the latest facts for the use of those responsible for the decisions. So this time too, although the decision makers were different, they had the same old input of "facts" upon which to reach a decision.

The situation which resulted in the scuttling of the ANP program must be guarded against in the future. Serious errors could also be made in our other vital atomic energy programs unless we learn from what happened in the ANP program. We must take the time to get up-to-date facts. We must look behind the fancy "position" papers we are presented with and do whatever is necessary to get at the pertinent facts to guide our decisions.

Status of ANP—I think one of the most unfortunate aspects of last month's decision to stop the ANP project is related to the status of the work at the time. A great deal of important progress was made in the last year. Major experiments were conducted to add a great deal of confidence to the designs. In fact, manufacture of a full-power nuclear aircraft propulsion plant unit for ground testing was ready to start. Many thousands of hours of tests were conducted under reactor operating conditions to prove out the materials and designs. Tests were conducted to the point of breakdown of the materials to obtain complete assurance on the adequacy of design margins. All of the information obtained confirmed the adequacy of the designs and in fact showed that significant growth margins were already in hand in the design. The status of the development, particularly for the direct cycle system which had a considerably greater amount of effort on it, clearly indicated that the next step should be a full-size integrated propulsion plant test. Going back to the laboratory bench, as called for by the new high temperature materials program being started to fill in for ANP, just doesn't contribute anything of significance toward getting on with nuclear flight.

Growth Potential Cliché—As you know, the ANP program was given a set of design objectives known as the "York criteria" for guidance in developing the first engines. This Defense Department criteria specified a subsonic aircraft since a possible mission was foreseen for such an aircraft and technical data clearly indicated the feasibility of meeting the criteria with the first generation of engines developed. In accordance with this "York criteria," work was going ahead to meet requirements. At the same time though, within the defense Department, a talking campaign was being conducted to give the impression that what was really wanted, and what was absolutely necessary to obtain a military useful aircraft, is multi-mach flight characteristics.

Fortunately, the nuclear aircraft developers had the foresight to look into the multi-mach growth potential of the individual cycles although their instructions were clear that the goal was, at the time, subsonic operation. The technical data that was developed, which the Joint Committee closely reviewd during the March hearing, indicated multi-mach potential was clearly present in the concepts under development. Unfortunately the picture on growth potential was not clearly presented, or it may not have been presented at all, to the new Administration.

Inconsistencies Apparent—Consistent with my belief that the facts were not made available to the decision makers are the apparent inconsistencies that now exist between the decision to drop the nuclear aircraft and the characteristics specified for our defense weapons. Take, for example, the Skybolt missile system recently earmarked for additional effort. It is planned to use conventional aircraft with their very limited range to provide a mobile launching platform for the intermediate range Skybolt missiles. A nuclear aircraft with, for practical purposes, unlimited range and endurance characteristics would increase the effectiveness of the Skybolt missile system tremendously.

The recently announced plan to keep one-eighth of our heavy bomber force on airborne alert points up another inconsistency relative to the decision to stop the nuclear aircraft. The unlimited endurance of nuclear energy sources gives a nuclear propelled aircraft enormous advantages in meeting such alert objectives. For the same airborne alert force a nuclear aircraft provides the potential for greatly reduced aircraft, personnel and support facility requirements.

Obviously the unlimited range which comes from nuclear aircraft endurance characteristics will open up completely new mission capabilities which cannot at present be foreseen. An idea of the military effectiveness which of such a revolutionary system can be obtained from our experience with nuclear submarines. Wouldn't it have been unfortunate if the unimaginative arguments advanced relative to the nuclear submarine turned out to be the controlling ones in that decision as they were in the nuclear aircraft decision?

I have pointed out many times that we could have had nuclear aircraft in flight today if it had not been for the "on again, off again" system of mismanagement by the Defense Department and its scientific advisers.

I can see the same approach creeping into the management of other defense projects and the Rover nuclear rocket program.

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Industry Urges Nuclear Rockets

Deep-space exploration and utility linked to nuclear power, Decisiveness now could result in space transport this decade; Early flight as third stage Saturn is basic industry goal

Staff Report

The gap has become a chasm. In orbiting and recovering a manned, 5-ton space vehicle, Russia has achieved what U. S. cannot hope for until the big Saturn booster becomes available in 1963-64.

What may be the last great hope for seizing leadership in the space race is the early development of a nuclear-powered space transport vehicle. The nation that acquires this capability first will achieve a dominance that outshadows anything achieved to date.

A current of urgency is beginning to flow through technical management in the aerospace industries. Many firms have plans for nuclear vehicles in the next ten years. The next step is to convince the Congress of the potential and feasibility of nuclear space ships and space stations.

Industry agrees that the most obvious and immediate place for nuclear engines is in the upper stage of Saturn. This is where the Rover-program engine will be tested. But steps must be taken now to speed Saturn, and develop engines beyond Rover if the advantage of nuclear space transport is to rest with this country.

Economics — A principal requirement of a nuclear transport system is reusability. By amortizing costs over a large number of flights such a plan becomes economically feasible. Space transportation need not be expensive. The cost of transporting cargo to the moon with a reusable nuclear system is estimated by Douglas Aircraft to be only ten times the cost of shipping the same cargo halfway around Earth by DC-8. Those are direct operating costs. What about the development cost of a reusable nuclear transport? It would be difficult to estimate. Douglas puts the cost at over one billion dollars, may be two billion. But certainly costs would not be out of line with those incurred during the jet engine revolution in aircraft, or the development of chemical rockets. The operating cost of a reusable nuclear system enjoys such an advantage over chemical systems that if the development cost one billion dollars it would be completely amortized after delivering only 400 tons of cargo to the Moon.

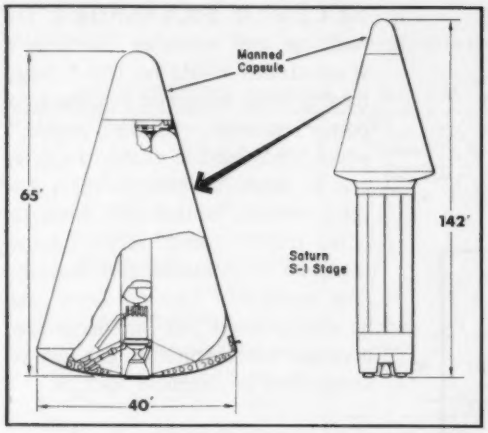
The Douglas Plan — Douglas Aircraft has configured a nuclear powered vehicle called RITA (Reusable Interplanetary Transport). RITA-A would haul a 10,000 lb payload to Moon; RITA-B would haul 25,000 lb. With one refueling enroute, payload could be raised to 38,000 and 90,000 lb respectively.

RITA-A is envisioned as being boosted by a first stage Saturn. Overall shape would be conical. The vehicle would leave the atmosphere nose first and reenter base first. Drag-weight ratio would be so high on reentry that the heat shield would be only a light structure. The device would also produce high lift and would cut deceleration loads to about 2 G's.

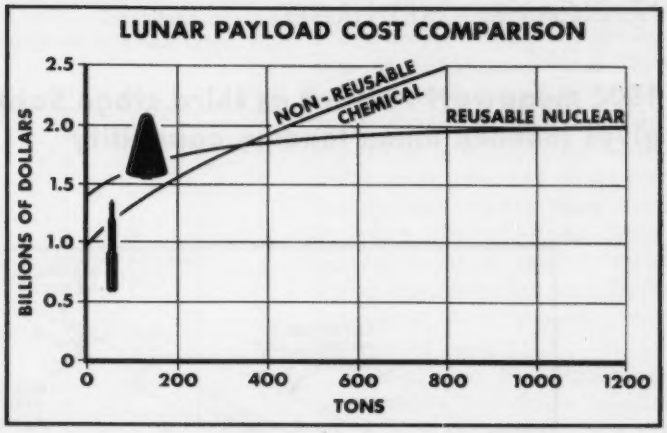
This is how Douglas views the main technical problems of development and operation:

(1) Reentry—Straight engineering solutions requiring hard work but no miracles would make multiple reentries possible. High drag, low maneuver techniques preferred.

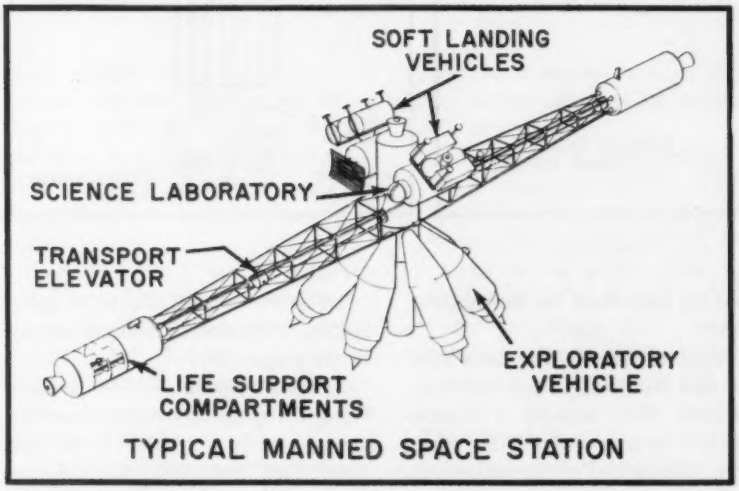
(2) Crew Shielding—Composite design together with appropriately dispersed fuel and cargo results in acceptable protection and weight.



DOUGLAS PROPOSES a Reusable Interplanetary Transport (RITA). "A" version shown. Boosted by Saturn it could put 10,000 lb on Moon without refueling, 38,000 lb with 1 refueling. Nuclear propulsion system is located within an outer tank cluster and below a central fuel tank. This gives clean aerodynamic geometry and obviates awkward support structures for vehicle landing. Landing bags are at eight locations about the base.



LUNAR PAYLOAD DELIVERY using nuclear propulsion systems starts to become more economical than chemical propulsion when cumulative payload weight reaches 400 tons. This analysis by Douglas takes into account only operating costs. Development of a reusable nuclear transport could run to $2 billion; but Douglas sees it as a "straight engineering problem." If development costs are considered the nuclear and chemical curves cross at 600 tons of delivered payload. A vigorous nuclear propulsion program could solve a whole family of space transport problems at once.



NORTHROP SPACE STATION replete with life support compartments, communications gear, interplanetary vehicle docks, refueling docks, etc., would weigh half-million pounds. It would be assembled in space with snap-on or plug-in units. Nuclear power would keep it in orbit. Station could accommodate 7-8 exploratory vehicles. The manned space station would orbit in excess of 500 mi. From this altitude a reasonably sized interplanetary vehicle could be launched. Launch from orbit was reportedly accomplished by Russia with vehicle scheduled to reach Venus May 19.

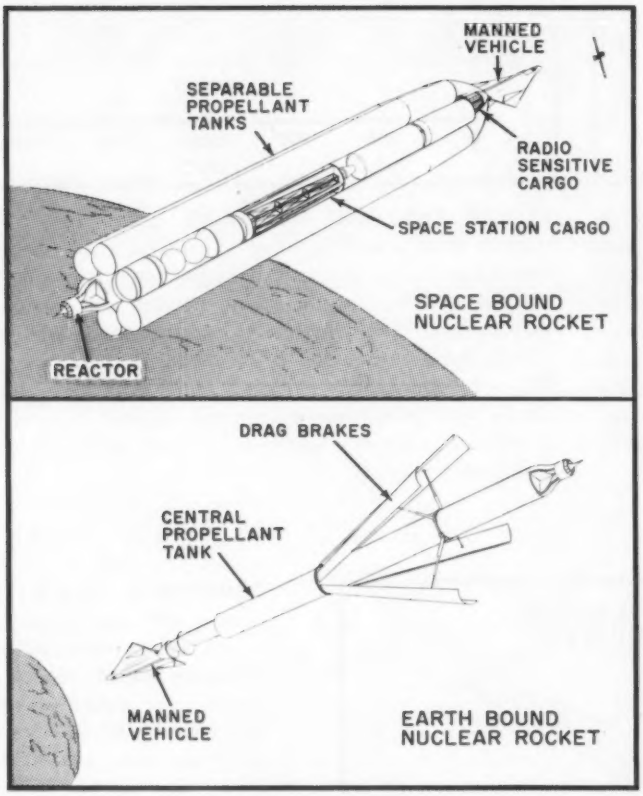
Flight reactor will throw off heaviest radiation in only short periods of full-power operation. Van Allen belt will be traversed in a few hours. Radiation from solar flares will be encountered for only a few hours.

(3) Flight Safety — A large psychological problem surrounds the possibility of radioactive debris falling anywhere on Earth should a mishap occur. No specific solution in mind, but confidence that answers can be found.

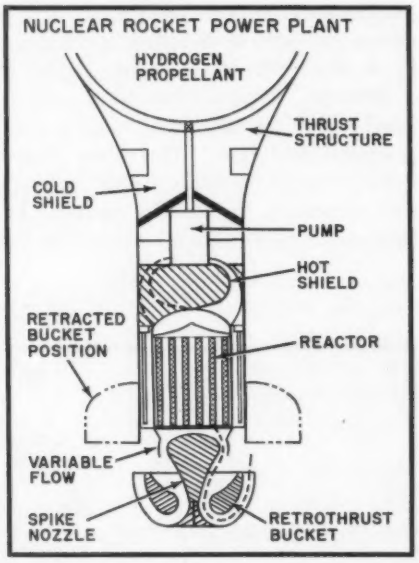
Douglas recommends a four step program: recovery techniques development using an LH_2-LO_2 upper stage; flight test Rover engine on Saturn; up-grade this prototype to 200,000 lb thrust (RITA-A); cluster four 200,000 lb thrust engines using the increased structural knowledge and specific impulse gained in the interim to fly heavier vehicle (RITA-B).

Northrop Plan—Nuclear powered space stations as well as space vehicles are being considered at Northrop. The space station would weigh about a half-million pounds and be assembled in space by

1500 megawatt reactor as third stage Saturn gives manned moon landing capability



NUCLEAR TRANSPORT for building and servicing Northrop's space station would be 150 ft long, have a 5000 megawatt reactor as a power source. "Spike nozzle," which lends itself to nuclear rockets, can be made to incorporate a reverse flow device that uses thrust to brake reentry speed. Retro bucket is shown in retracted and reverse-flow positions. Moving parts can be incorporated into nozzle design because temperature of exhaust is lower than in chemical rockets.



rendezvousing components and joining them by snap-on devices.

Nuclear rockets, according to Northrop offer good potential in:

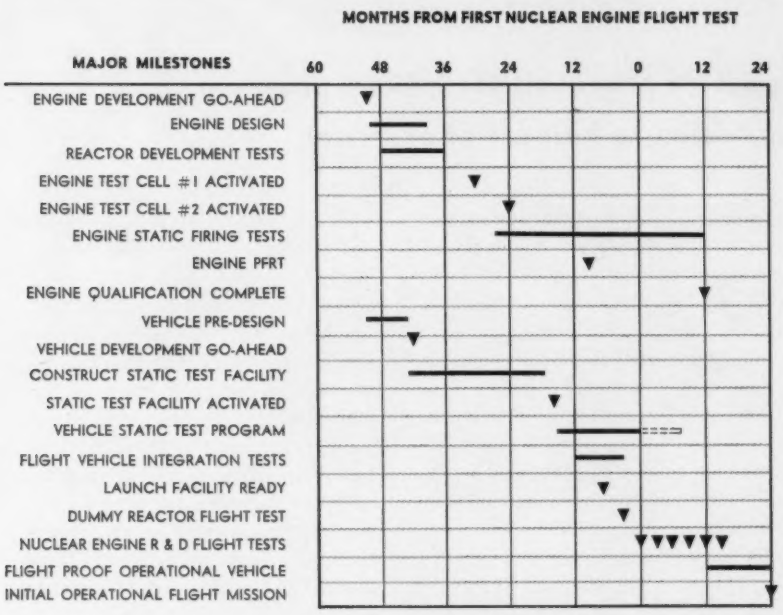
(1) high lift capability; (2) maneuvering in orbit; (3) controlled reentry; (4) multi-manned capability.

Assembling a station in space would require a nuclear ferry. The reactor itself would have to be of 5000 megawatt rating. Marrying the reactor to a large chemical booster would give a payload orbit weight of 125,000 lb. To return to Earth from orbit with a 20,000 lb vehicle would require about 100,000 total lb if the reactor were used for deceleration in reentry. This means that a net payload of 25,000 lb could be deposited by the nuclear ferry.

What would a nuclear ferry look like? One Northrop design envisions a vehicle built around a central tank 150 ft long and 20 ft in diameter. At one end of the tank there would be a special cargo space and a manned vehicle for orbit maneuvering and return to Earth. This manned vehicle would be the 20,000 lb return payload previously mentioned. Toward the powerplant end of the vehicle, a cluster of propellant tanks would be arranged around the central tank so as to be separated upon consumption of their propellant. Space station parts also would be arranged in cluster fashion around the central tank.

The pilot would release all space station components simultaneously at the proper orbit.

Liquid Shields — In nuclear flight, the question of crew shielding always evolves. Aside from the powerplant shielding, there is an appreciable shielding in the Northrop design by the central propellant tank, and the cargo structure intervening between the nuclear reactor and the manned vehicle. For extra safety, however, the manned vehicle would be additionally shielded. This additional shielding would consist of two types; consumable and non-consumable. Both would be liquid. The consumable would be a boron jet fuel, which is an excellent shield against neutrons. The non-consum-



DEVELOPMENT CYCLE proposed by Convair Div. of General Dynamics sees only 48 months between "go" and first flight test. Nuclear rocket would be operational in 75 months.

able portion would be mercury to shield against gamma rays. Being liquid, both shields could be: (1) pumped to intense radiation areas; (2) used for cockpit temperature control; (3) jettisoned in emergencies.

Rendezvous is usually considered a large problem in space station assembly. But the problem diminishes with nuclear propulsion. nuclear rocket will have a great energy reserve and thus will be very maneuverable.

Incorporating moving parts into rocket nozzles is not good design practice in chemical rockets, but the temperature in nuclear rocket nozzles is about 2000°F lower. Using a "spike nozzle" and the lower temperature a design can be envisioned to give the nuclear rocket back-and-fill and full retrothrust capability (see illustration). This design would be useful in reentry. Instead of relying solely on ablative nose cones, skip gliding, drag surfaces, etc., the nuclear craft would use reverse thrust, as a jet airliner uses reverse thrust to cut its landing roll-out.

The reactor must always be brought back to Earth. Northrop thinks that reusability is not the criterion for bringing it back. There remains in the reactor close to $4 million worth of unused fuel. This is the "criticality fuel", used to maintain the nuclear fission at self-sustaining temperature. The criticality fuel is never fully consumed. The "power fuel" is consumed and represented on a small part of the total nuclear fuel.

The Convair Plan—Operational vehicles could be operational about 75 months from go ahead according to Convair. This means that if the program were given active support today, nuclear upper stages would be fiying operationally on Saturn in 1967-1968. First flight could take place in 48 months (spring 1963).

Though Convair is involved in such exotic nuclear propulsion programs as Project Orion (propulsion by nuclear explosions) they consider it wise not to wait for full development of all-nuclear systems. Thus, they join a chorus of other companies who feel the most logical and urgent step is to marry the nuclear rocket to the chemical rocket now. The chemical rocket would of course be Saturn. Convair's Krafft Ehricke recently called for nuclear power, stating that chemical rocket fuel is impractical for "manned travel beyond the moon."

NASA, who has development responsibility for Saturn concurs that nuclear upper stages should be flown on the huge booster. One design sees a 3-stage configuration 250 ft high. The third stage would be a 75,000 lb thrust nuclear engine. It would put a 15-ton manned spacecraft with a chemical fourth stage into low Earth-orbit. After refueling in orbit from Saturn tankers, the 100-ton vehicle would depart for a Moon reconnaissance flight. The LO_2-LH_2 fourth stage would be used for return to Earth.

This chemical-nuclear Saturn configuration has also been offered by NASA as a means of accomplishing a manned landing on the Moon.

The reactor envisioned would have a power level of about 1500 megawatts, and use hydrogen as a working fluid.

North American View—A well-planned development program for a nuclear rocket engine should be an immediate goal, according to NAA. The present level of funding, if continued much longer, constitutes a waste of time and funds. NAA thinks, along with the rest of industry that a nuclear upper stage for Saturn is the most immediate flight goal.

For a manned Mars flight NAA thinks a six man crew is a must to monitor and control instruments on alternating shifts. Minimum payload would be 100,000 lb exclusive of shielding. The shield weight could reach 80,000 lb. Chemical rockets are not capable of transporting 180,000 lb to Mars. NAA says nuclear engines, boosted by vehicles as large as Nova, must be ready to do the job.

NASA-AEC review industry proposals for NERVA program, Vehicle and facilities design to be part of contract

Lockheed's Studies — Initial nuclear work at Lockheed concentrated on effect of shield weight on Moon-Mars mission. It soon became apparent that shield weight could be considerably reduced by using nuclear power as upper stages rather than lower stages. Lockheed too turned to Saturn, showed that payload capability of a Saturn with an unsophisticated nuclear third stage is twice that of the best all-chemical Saturn. Lockheed's planners see a flight test during the latter half of 1965 as a realistic goal. This would require full ground test of flight-type reactor during the first part of 1963.

Thiokol Appraisal — Thiokol estimates that the effort expended by industry in developing nuclear rockets over the past five years is only ten per cent of what must be expended in the next five years. Thiokol waves a caution flag however in beginning too much of this work before completion of reactor tests with liquid hydrogen. Although there are no state-of-the-art break throughs needed, development of pumps, nozzles, and controls have just begun, and the main problem will be efficiently integrating them into a dependable nuclear rocket. Thiokol seems to be in general accord with the NASA plan which encompasses KIWI, NERVA, and RIFT. But, the company says, management must maintain a feeling of urgency about the program.

These views are not limited to the companies mentioned, many others share the feeling that a nuclear stage for Saturn is an urgent need.

Program Status — One of the first steps in developing a nuclear reactor for space missions was the construction of a "proof-of-principle reactor." It was never intended that this reactor should fly. It was therefore dubbed KIWI, after a New Zealand bird which never takes to the air.

Three KIWI-A reactor experiments were conducted between July 1959 and October 1960. All of the experiments were run with gaseous hydrogen as a propellant and water as a coolant for the reactor shell and the jet nozzle. The tests were very successful.

The next phase of KIWI tests will use liquid hydrogen as a propellant and as a coolant. This will be known as the KIWI-B series, and tests should begin before the end of the year. Rocketdyne is developing the hydrogen turbopumps and nozzles. The KIWI-A test cell is being modified to accommodate the new reactor. An additional test cell will be constructed to more closely represent conditions which a flight-type reactor will experience.

Ground support and test facilities for future nuclear testing will be complex. NASA has plans to build a National Nuclear Rocket Development Facility. Contractor selection is due soon. One of the devices that must be included in this complex is a down-firing reactor test stand. KIWI tests have all been fired upward. Aerojet-General Corp. is now designing such a stand at its Aetron Div.

RIFT and NERVA—The joint AEC-NASA Nuclear Propulsion Office (NPO) which has responsibility for the rocket propulsion program set April 3, 1961 as the deadline for proposals on a new program called NERVA (Nuclear Engine Rocket Vehicle Application). This is an extensive study that will proceed logically to the first nuclear engine from the reactor program now underway. First phase of the NERVA work will include design of the engine, a development program plan, some R&D work, assisting the Los Alamos Lab in conducting KIWI-B tests, and design of engine and vehicle facilities for the program. It is more than a propulsion study as is the case in Rover.

In addition to these studies, there is a program to evaluate the various way of flight testing nuclear rocket stages. This program is called RIFT (Reactor In-Flight Test). Lockheed, Missiles and Space Div., and Martin-Denver are working under cost sharing contracts. Douglas and Convair-Astronautics are working under $1 contracts. NASA will probably award a complete RIFT contract for the final development of a vehicle that grows out of early RIFT and NERVA work propulsion system. NPO will no doubt direct and integrate the industry teams. This seems a logical plan for early flight test is properly implemented.

The broad objectives of the AEC - NASA nuclear propulsion program as they now stand are summarized as:

(1) Demonstrate feasability of nuclear rocket engine through ground testing the NERVA engine.

(2) Demonstrate the operation of high power density reactors for advanced space missions.

(3) Conduct continued research on advanced reactors and non-nuclear components to provide higher temperature in lighter weight systems.

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Designer's Decision Guide For Nuclear Rockets

Radiation sensitive parts and materials evaluated in specific systems where they must operate; Data lacking on combined cryogenic-radiation environment

by W. L. Fink, Senior Nuclear Engineer and
J. W. Gordon, Nuclear Engineer, Convair-Fort Worth

Three techniques for using nuclear propulsion in rocket systems have been conceived. One involves controlled release of the products of a nuclear explosion; however, the control of thrust and the containment problems associated with this technique are obvious disadvantages. Another technique is based on using a nuclear power plant as the energy source for an ion propulsion system. This mode of propulsion is ideal for low thrust, long run-time systems but it would not be very suitable for boost vehicles. The third technique entails using a fission reactor as a heat source for a combination coolant - propellant. This is the most logical principle for primary nuclear rocket systems. The propellant would be liquid hydrogen.

This system is a promising means of propulsion for both large booster vehicles and spacecraft. But there are various phenomena associated with the nuclear environment that influence vehicle design, systems designs, and missions.

The aspects of nuclear engineering that are pertinent to nuclear rocket design include radiation damage, shielding, safety, activation, instrumentation, and reactor design.

Radiation Damage — The response of any operational system to nuclear radiation is governed by the effects on its materials and parts. The procedures involved in the prediction of system response to a nuclear radiation environment are in Fig. 1.

To minimize redundancy in data analysis, the materials and components of a nuclear rocket are classified under five major systems. Each of these systems is composed of various sub-systems and assemblies. The radiation damage analysis of each major system is resolved by the individual analyses of the radiation sensitive parts of the applicable subsystems and assemblies. Fig. 2 depicts the five major systems with their respective radiation sensitive parts or materials.

Airframe System—Items considered in a radiation damage analysis of the airframe, comprise the propellant tank, the nuclear engine support structure, the nose cone structure, the propellant pumping equipment, thermal insulation, and nuclear shielding materials. The items in this system that are relevant to the radiation damage analysis are metals, thermal insulation, and adhesives. (See Fig. 2.)

The results of the analysis of the structural metals data indicate that at temperatures ranging from about 75°F to 500°F, nuclear exposures greater than 1.0^{18} n/cm² are required to produce mechanical property changes which exceed 10 percent of the unirradiated property value. However, should a propellant such as liquid hydrogen be used, some of the metals would be exposed to cryogenic temperatures in addition to nuclear radiation. There are not yet any published experimental data on the mechanical properties of metals under irradiation at cryogenic temperatures. Recently, this type of testing was conducted at Convair-Fort Worth. The data obtained from this experiment will soon be analyzed and a prediction of metal stability will be made.

Thermal insulation will be required around the propellant tank. The results of the data analysis on organic, inorganic, and mineral types of thermal insulation indicate that the inorganic and mineral insulations have functional thresholds in excess of 1.0^{15} n/cm². Experimental data on organic thermal insulations are limited, but an estimate of 1^{7} to 5^{11} ergs/gm(C) for functional thresholds was made. These data indicate that it will be possible to select a suitable thermal insulation for the anticipated nuclear environments.

Explosion at launch or reentry of nuclear rocket could spread radiation over populated areas

Thermal insulation can be bonded to the propellant tank with an adhesive or it can be sandwiched into an insulation shell and mechanically attached. If the thermal insulation is bonded, the upper limits of radiation tolerance will be determined by the adhesives. The presently used adhesives have thresholds in the order of 1^{10} ergs/gm(C). However, insulation can easily be mechanically attached and in this case radiation damage should not present a problem.

The results of the analysis of the airframe system show that experimental data are needed to predict the effect of nuclear radiation on metals at cryogenic temperatures. These results also indicate that it will be possible to select a suitable thermal insulation for the anticipated nuclear environment by using the more radiation resistant materials without shielding. Typical insulation materials that will be satisfactory are Refrasil or glass fiber.

Propulsion System—The reactor assembly, the reactor control assembly, and the cryogenic pumping equipment make up the propulsion system.

The reactor control assembly consists of the control rods, actuators, ion-chambers, and a servo control mechanism. The radiation sensitive items that may be part of this equipment include lubricants, pneumatic seals, back-up rings, and electrical insulation. The radiation damage problems that may result from the use of these items may be reduced by using hot-gas pneumatic actuators, dry-film lubricants, and replacing organic seals and back-up rings with metallic ones.

If the conventional organic seals, back-up rings, and lubricants are used in the reactor control assembly, radiation damage problems will result because the maximum anticipated radiation dosage is relatively high in this region. The use of dry film lubricants is preferable to that of organics because it has been estimated that the dry film lubricants have functional thresholds in excess of 1^{11} ergs/gm(C). Organic lubricants have lower functional thresholds, ranging from 1^{8} to 1^{11} ergs/gm(C). The conventional organic seals and back-up rings are unsatisfactory for use in this assembly because their functional thresholds range from 2^{8} to 6^{9} ergs/gm(C) and from 1^{7} to 9^{8} ergs/gm(C), respectively. However, if it is feasible to use metallic seals and back-up rings, radiation damage will be alleviated because their functional thresholds will be in excess of 1^{18} n/cm^2.

Electrical insulation will be required in the servo valve electrical connections and in the ion-chamber. These components will be located in high flux regions. Since the functional thresholds for electrical insulation range from 1^{7} to 5^{11} ergs/gm(C), it is predicted that only the most radiation resistant organic insulation will survive.

The only radiation sensitive items in the cryogenic pumping equipment will be the seals. The cryogenic pump will be subjected to high radiation fluxes and cryogenic temperatures. Since there are no experimental data on the combined effects of nuclear radiation and cryogenic temperatures on seals, it is impossible to predict the serviceability of the cryogenic seals.

If the materials in the propulsion system are carefully selected for maximum radiation resistance and the control rod actuators are located on the reactor core, shielding attenuation factors of 1.8^{-2} for neutrons and 9^{-3} for gammas will be required. If the actuator location is revised, the attenuation requirements will be 6^{-2} and 2.2^{-2} for neutrons and gammas, respectively.

Electronic Systems — Electrical and electronic equipment will be located in the electronic bay of the nose cone and in the cryogenic pump area. Radiation damage in the equipment in the former area will be negligible because the radia-

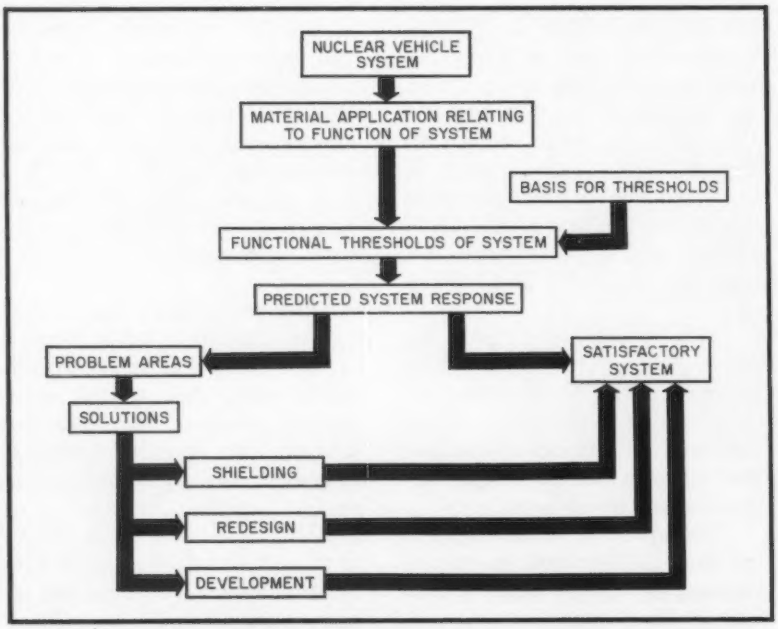

FIG. 1. PROCEDURE FOR PREDICTING system response to nuclear radiation has been evolved by Convair. It is used in current studies on nuclear rocket.

tion levels will be relatively low due to the shielding effect of the propellant. The equipment located in the pumping area will receive much higher fluxes. Radiation sensitive items will include gyro fluids, electrical insulation, seals, back-up rings, and transducers.

Careful selection of the most radiation resistant transducers and electrical insulations will minimize radiation damage considerations in the higher flux regions. If the conventional back-up rings and seals can be replaced with metallic ones, satisfactory performance can be achieved. However, the use of even the most radiation resistant gyro fluids requires shielding attenuation factors of 3.3^{-2} and 1.2^{-2} for neutrons and gammas, respectively.

Secondary Power System—This system contains the attitude control assembly and turbine drive assembly for propellant pumps. The radiation susceptible items in this system include lubricants, seals, gaskets, back-up rings, and seat discs and packing. These items will be located in relatively high flux regions. If dry film lubricants and metallic back-up rings and seals are used, radiation damage will be minimized to tolerable limits.

If the most radiation resistant materials are used in the secondary power control system, shielding attenuation factors of 4^{-2} for neutrons and 4.5^{-2} for gammas will be required.

Auxiliary Systems—The auxiliary systems of the nuclear rocket include the environmental control, stage separation, and flight termination systems. A radiation damage analysis of the environmental control system was omitted in our tests. The equipment for the stage separation system is required to perform its functions at the beginning of nuclear flight and even though the flux levels would be high, the dose at the time of separation will be low enough that no radiation damage problems are expected.

Flight termination may be effected by one of two methods: an abort or escape mechanism (for manned vehicles) in case of a malfunction during launch or boost phases of the flight, or recovery of a relatively intact vehicle after a successful mission. The equipment in the abort system will not suffer radiation damage because the radiation levels during launch operations will be very modest.

If flight termination is resolved by the complete vehicle recovery, the recovery process will involve three specific phases: (1) Atmospheric re-entry by using the primary propulsion system as a retro-rocket, (2) Parachute descent through the atmosphere, and (3) Landing. If a water landing is made, the reactor will have to be sealed to prevent flooding of the core.

The radiation sensitive items in the recovery equipment included parachute materials, marker beacon balloon materials, and seals, gaskets, and back-up rings in the reactor seal actuating device. The first two items will be located in a low flux environment so radiation damage will not be a problem. The reactor sealing actuator will be located in a high flux region and minimum shielding attenuation factors of 1.8^{-1} for neutrons and 9^{-3} for gammas will be required if organic seals, gaskets, and back-up rings are used. However, radiation damage problems could be avoided by using a hot-gas pneumatic actuator with metallic seals.

Shielding—Personnel in a nuclear rocket vehicle must be shielded from the air scattered radiation, the direct beam radiation, and space radiation. Fig. 3 shows that the magnitudes of the shielding requirements for these radiation sources are dependent upon the mode of operation of the vehicle. A one-stage vehicle designed for outer space operation will require shielding from all of the radiation sources. In a chemically boosted nuclear vehicle the air scattered radiation will be practically non-existant if the nuclear power is not applied until the vehicle is out of the atmosphere. If the vehicle is used for very low altitude ballistic missions, the hazards from space radiation become negligible. Although the direct beam radiation cannot be modified by the zone of operation of the vehicle, it is possible to lower the direct beam

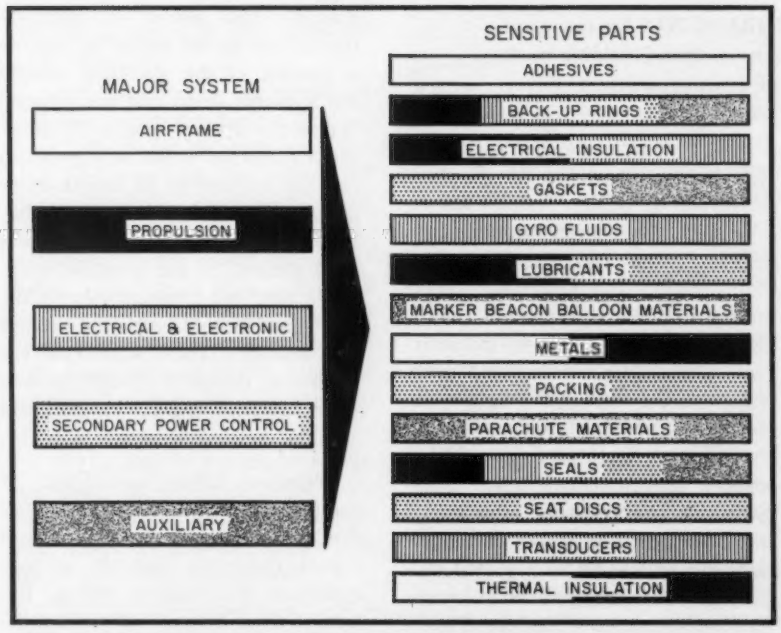

FIG. 2. TO MINIMIZE REDUNDANCY in data analysis materials are evaluated in the five major rocket systems. The sensitive materials in each system are shown.

Use of radiation resistant components could reduce shielding weight to about 2200 lb

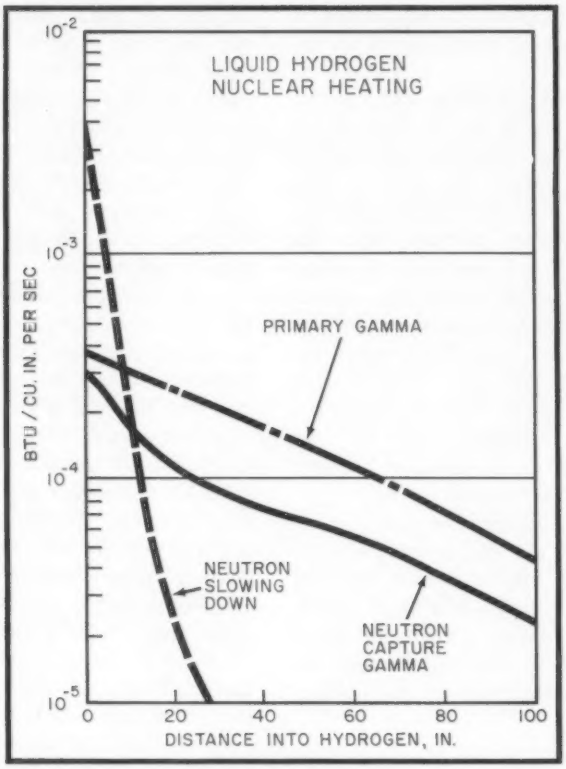

FIG. 3. SHIELDING REQUIREMENTS for man and equipment vary with mode of operation. Shielding must be provided, however, for air scatter radiation, direct beam radiation, and space radiation.

shielding requirement by placing the propellant tank between the power source and the crew station.

In unmanned versions of nuclear rockets, the shielding requirements are dictated by nuclear heating rates in the propellant and physical damage to subsystems or materials.

If the available radiation resistant materials are used, the attenuation requirements for protection of the systems in a typical nuclear rocket vehicle are about 1^{-2} and 3^{-2} for gammas and neutrons, respectively. These requirements can be satisfied by using 15 in. of polyethylene for neutron attenuation followed by 3 in. of depleted uranium for gamma attenuation. This results in a total shield weight of about 4700 lb. If certain systems are redesigned, these attenuation requirements can be relaxed to 5^{-2} and 1^{-1} for gammas and neutrons, respectively. These requirements can be satisfied by using 9 in. of polyethylene and 1.3 in. of depleted uranium, and the total shield weight will be about 2200 lb.

Nuclear heating of a liquid hydrogen propellant can cause excessive pressure build-up in a sealed tank or can cause a loss of propellant due to boil-off in a vented system. Particle interactions in hydrogen cause nuclear heating. Fig. 4 shows that the heating effect involves three primary processes. The major amount of heat energy is added to the hydrogen by the slowing down of neutrons. These slow neutrons are easily captured by hydrogen resulting in the emission of a nominal 2 mev gamma photon which deposits heat energy into the propellant.

The hydrogen attenuation of gamma photons emitted directly from the reactor, contributes to the heating of the propellant. One possible solution to the prevention of excessive nuclear heating is to use a nuclear shield which is especially designed to attenuate the energy of the radiation beam. It is necessary to use about 1300 lb of shielding to obtain a nuclear heating attenuation factor of 1×10^{-1}. This shielding can be a material that will withstand high temperatures or it can be a lower temperature material cooled by various combinations of radiant and/or forced convective cooling.

Divided vs Unit Shields—The ideal geometry of nuclear rocket shielding depends upon the areas which require protection and the types of radiation environment encountered. A divided shield is ideal for most vehicles requiring shielding from air scattered or space radiation. This allows an optimization of net shield weight by placing a portion of the shielding around the sensitive items and the remainder on the nuclear source. If direct beam radiation is the only problem and the objects to be shielded are large, then a unit shield on the nuclear source is the most efficient arrangement. If the sensitive items are located in a compact volume, the unit shield should be placed around that volume. These variations are subject to design trade-offs for any given nuclear rocket vehicle and mission.

Nuclear Safety — Release of gamma and neutron radiation, fission products, and chemically-toxic vapors constitute hazards to safe operation of a nuclear rocket. Effects of these hazards influence utilization of the launch site, selection of vehicle mission profiles, and establishment of exclusion areas as re-

TABLE I

MAGNITUDE OF HAZARD UNDER NORMAL AND FAILURE CONDITIONS

NORMAL OPERATION	NUCLEAR LAUNCH MILES	CHEMICAL LAUNCH MILES
Reactor Radiation (10 millirem)	1.3	0.3
Fission Product Cloud (60 millirem)	2.5	0
Ground Contamination (60 millirem)	3.7	0
ACCIDENT-LAUNCH		
Reactor Radiation (25 rem)	0.5	0.5
Fission Product Cloud (300 rem)	0.6	0.6
Ground Contamination (300 rem)	0.2	0.2
Toxic-Chemical (25 microgram/m³)	2.5	2.5
ACCIDENT-IMPACT		
Reactor Radiation (25 rem)	0.5	0.5
Fission Product Cloud (300 rem)	2.3	2.3
Ground Contamination (300 rem)	1.6	1.6
Toxic-Chemical (25 microgram/m³)	2.5	2.5

quired for protection of the general public.

Potential hazards are based on the location of mishap. Three specific locations were studied: launch site and surroundings, flight path, and impact site. The nature of the hazard is dependent upon the location of occurrence of the specific phenomenon.

Launch hazards are dependent on the type of launch. The nuclear rocket may be used as a first stage or as an upper stage on a chemical boost vehicle.

Hazards that are the results of plausible accidents during the nuclear launch are the release of fission products and the release of chemically-toxic compounds. The release of fission products can occur when reactor power excursions cause vaporization of a portion of the reactor core. The release of chemically-toxic compounds can result from burning some types of neutron reflectors in a launch pad fire.

If the nuclear rocket is an upper stage, the release of fission products and direct radiation from normal reactor operation should not be of any major importance.

One hazard consideration for a ballistic trajectory is that there will be very little time for the fission products generated during reactor operation to decay. This will result in the release of relatively large quantities of short-lived isotopes. All of the short-lived isotopes will have decayed before the return of the vehicle if an orbital trajectory is used. These factors show that return from an orbital mission will cause less contamination than from a ballistic mission. But an important consideration for the orbital mission is that there is no assurance that release in populated areas can be avoided under conditions of a reentry malfunction. This is one consideration that has influenced leaning towards a ballistic flight test trajectory for early nuclear rockets.

Table I gives the order of magnitude of hazards for a typical nuclear rocket vehicle under operating and failure conditions. The criteria are based on an allowable unmonitored exposure for normal operations and on a once in a lifetime exposure for accidents.

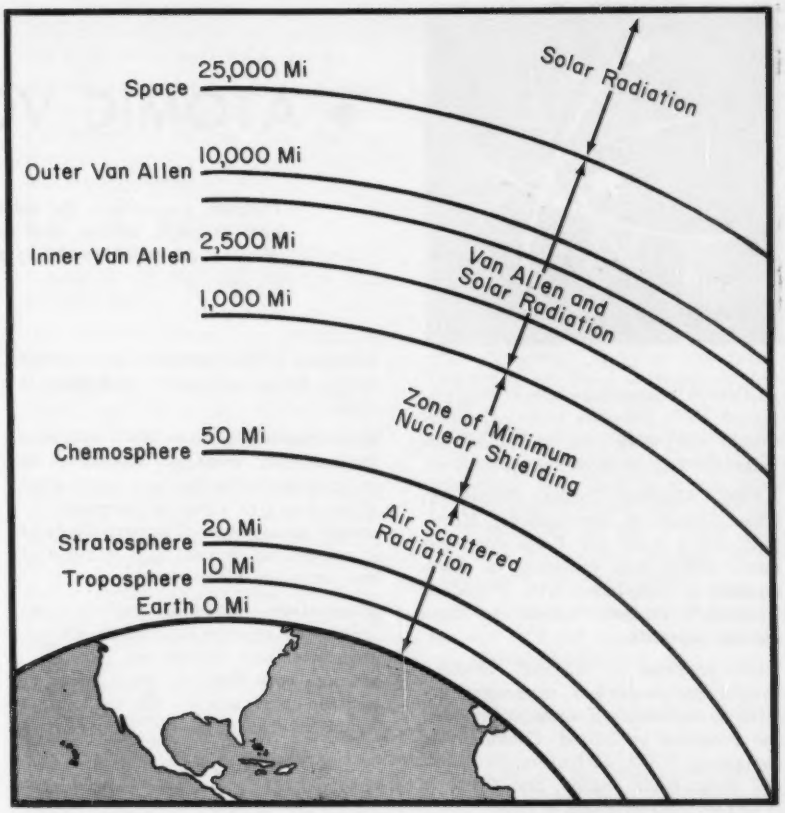

FIG. 4. NUCLEAR HEATING of liquid hydrogen propellant can cause pressure buildup—or boil-off. Heating comes from three effects. Major input is from slowing down of neutrons.

The exclusion areas take the form of an isopleth lobe downwind from the site of an accident for fission products, or a circular area in case of direct reactor radiation. Those hazards which involve wind direction are biased by the existence of atmospheric inversions. The inversion condition causes a much larger exclusion area for any fission product release accident. No nuclear vehicle launchings should be attempted during inversion conditions. An example of the effects of an inversion is that of a launch accident; the exclusion isopleth lengths based on a fission product cloud are 0.6 mi and 1.6 mi for the lapse and inversion conditions respectively.

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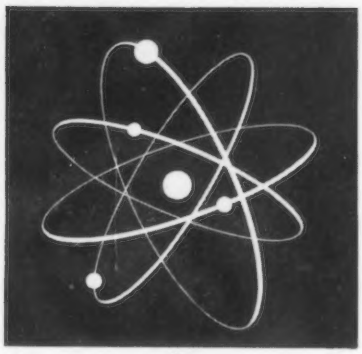

• ATOMIC VOCABULARY •

Nuclear propulsion for aerospace vehicles has generated new projects, offices, and teminologies. This basic vocabulary is essential to doing business in nuclear propulsion.

– A –

ALOO—Albuquerque Operations Office of AEC. Provides technical direction of AEC work done by Los Alamos Scientific Lab on Rover project.

ANPO—Aircraft Nuclear Propulsion Office, located at Germantown, Maryland. Joint AEC-Air Force management. Office will probably be reorganized in compliance with President Kennedy's budget request to drop nuclear aircraft.

ANP program — Aircraft Nuclear Propulsion program managed by ANPO. President Kennedy requested the program be halted. Convair was designing NX-2 airframes for both GE direct-cycle engine, and Pratt & Whitney indirect-cycle engine.

ASP—Aerospace Plane, a proposed Air Force project for a vehicle that would take-off and land as a normal aircraft, yet have the ability to climb to 300-mi orbit. Would use liquid hydrogen as fuel, compress, liquify and store atmospheric oxygen for oxidizer.

ASTR—Aircraft Shield Test Reactor, a device developed for nuclear aircraft tests at Convair-Fort Worth. Reactor has flown in conventionally powered B-36 during two-year test period.

aftercooling—The process of cooling a nuclear reactor after it has been shutdown. Excess heat generated by continuing radio active decay of fission products is carried away by pumping a coolant through the reactor.

afterheat—The heat which continuing radioactive decay of fission products produces in the reactor core after shutdown.

air scattering—Process of dispersing radioactive particles as they collide with molecules and atoms in the air.

alpha emitter — A radioactive substance that decays by emitting alpha particles.

alpha particle—A positively charged particle emitted from the nucleus during radioactive decay. It consists of 2 neutrons and 2 protons, hence is identical to the nucleus of a helium atom. Range of alpha radiation is small in air.

annealing—A process for returning radioactively damaged structures to original condition through application of heat and/or electrical current.

atomic percentage—The percentage of atoms of one element in a mixture of two or more elements.

attenuation — Reducing radiation intensity by passing it through matter, absorption and scattering.

average core flux—Average value of neutron flux across the core of a reactor.

– B –

BOLA—A concept for manned nuclear space vehicle wherein a long cable separates the manned capsule from the reactor. Need for heavy shielding is thus reduced.

background effect—Interference from foreign or stray radioactivity.

bare core—A reactor core with reflector removed.

beta energy—The energy of a beta particle in electron volts.

beta particle—A high-speed particle emitted from the nucleus during radioactive decay. This radiation consists of electrons, positrons (positive or negatively charged). Emission of the negative particle entails the change of a neutron into a proton inside the nucleus. Emission of the positive particle entails the change of a proton into a neutron.

bimetal—A material or system composed of two different metals i.e., molybdenum-plutonium.

burnup—Depletion of fuel in a reactor by fission, or the percentage of depletion.

buzz—An oscillating motion in ramjet aerodynamics induced by airflow instability. The resulting shock and pulsations can destroy the engine.

– C –

CAMAL—Air Force project for Continuously Airborne Missile Launcher and Low-Level Penetration airplane (cancelled).

CANEL — Connecticut Aircraft Nuclear Engine Lab where Pratt & Whitney has been investigating materials for the indirect-cycle nuclear aircraft engine. Built 1955 at Middletown, Conn.

capture—Acquisition of an additional particle by a nucleus.

Carnot efficiency—An idealized heat cycle (Carnot cycle) expressed as the ratio of worked delivered to the heat received from the source.

cermet—A fused combination of ceramic and metal. Used where high temperatures are encountered.

cladding—A bonded coating on nuclear fuel materials to protect from loss of fission products, corrosion and erosion.

elastic collision—A collision between two particles in which no change occurs in the internal energy of the particles, or in the sum of their kinetic energies. Also referred to as a billiard-ball collision.

inelastic collision — A collision between two particles in which changes occur both in the internal energy and in the sums of their kinetic energies.

control swing—The amount of control-rod movement, from start-up to operating point of a reactor, that is necessary to prevent reactor shutdown at high temperatures.

critical — Capable of sustaining a chain reaction.

criticality factor—In a reactor, the numerical value of the effective multiplication factor (k_e), denoting the degree to which the reactor has achieved a self-sustaining chain reaction.

critical mass—The amount of concentrated fissionable material that can just support a self-sustaining fission reaction.

critical reactor—The steady-state condition of a reactor in which the neutron fission process is self-sustaining.

critical temperature — The tempera-

ture at which the least resistant component of the reactor core begins to melt down with over heat or after heat.

cross section—The probability of occurrence of an interaction between a nucleus and an incident particle or photon. The cross-section quantity may be considered as the effective target area that the nucleus presents for the reaction. It is measured in area units expressed as barns (1 barn = 10^{-24} cm^2).

cryogenic temperature—Very low temperature range—below —50 deg C. Concerns temperatures in the range of liquefied gases.

curole—A unit of radioactivity defined as the amount of radioactivity which undergoes 3.7 x 10^{10} disintegrations per second.

– D –

daughter element—The decay product of a specific radioactive element that decays by other than gamma emission.

decay—Decrease of a radioactive substance because of nuclear emission of alpha or beta particles, positrons, or gamma rays.

depleted uranium—Uranium containing a lower percentage of the U^{235} isotope than is naturally found in mined uranium (0.07 per cent).

diffusion—A high percentage of scattering of particles during passage through a substance.

direct air cycle—A propulsion cycle in which air is the working fluid. It is successively compressed in the compressor section, heated in the nuclear reactor, and expelled through the turbine-tailpipe section to obtain thrust.

dissociation—The process of ionizing a molecule of matter into two ions, one positively charged and one negatively charged.

– E –

effective neutron cycle time—The lifetime of an average neutron within a reactor from the time it is produced to the time it is fission-captured.

electrical kw-year—A unit for electrical power rating: one kilowatt of electrical energy produced continuously for one year.

electromagnetic radiation—Radiation resulting from fission or radioactive decay that is of wave form rather than particle form.

electron-positron pair—Pair production resulting from a gamma ray interacting with a charged field. The pair consists of two electrons—one with the normal negative charge, and the other with a positive charge.

electron volt (ev)—The energy needed to raise one electron through a potential difference of one volt. Nuclear energy is usually expressed in million electron volts (mev).

– F –

FETF—Flight Engine Test Facility, located at the National Reactor Test Station, Idaho.

fast neutron—Usually a neutron of 100 kev or greater energy.

fast reactor—A reactor containing no moderator. Thus all fissions take place at energies on the order of 100 kev or greater.

fast reactor period—A reactor period in which the rate of power increase is large enough to make the control of the reactor extremely difficult.

fission products—Particles which results from a fissioned nucleus. The fissioned nucleus splits into two lesser nuclei that are usually radioactive and highly energetic.

fission wastes — The irradiated fuel elements removed from a reactor that must be contained and disposed of while they are still radioactively "hot."

flux—The number of radioactive particles per unit volume times their mean velocity.

gamma flux—The total gamma energy emitted per square centimeter per second.

neutron flux—The sum of the distances traveled by all the neutrons in one cubic centimeter in one second. Normally the figure must be energy qualified e.g., thermal, intermediate, or fast neutron flux.

free-stream capture area—The cross-sectional area of a column of air injested by a ramjet engine.

– G –

GE-ANPD—General Electric Aircraft Nuclear Propulsion Department formed in 1951. Research and development work is carried on at the Air Force-owned-and-GE-operated plant at Evendale, Ohio. The GE-ANPD testing site is located at AEC's NRTS in Idaho.

GNAL — Georgia Nuclear Aircraft Laboratory. An Air Force-owned radiation-effects facility built in 1956 at Dawsonville, Georgia, and operated by Lockheed Aircraft Corp. It is designed to irradiate and test large aircraft components and major subsystems anticipated for use in nuclear-powered airborne vehicles.

gamma energy — The energy of a gamma ray, ranging from 10^6 to 10^7 electron volts.

gamma radiation — Electromagnetic radiation of wave form emitted by a radioactive nucleus. Similar to X rays but of higher energy and shorter wave length.

– H –

HARAO—The Hartford Aircraft Reactor Area Office, a field extension of LAROO located near Middletown, Connecticut, at the Connecticutt Aircraft Nuclear Engine Laboratory (CANEL) of Pratt & Whitney Aircraft.

HTRE—Heat Transfer Reactor Experiments, a joint Air Force-AEC development and test program since 1951 to determine the characteristics and feasibility of the reactor core, shielding, and control designs for the direct-cycle nuclear turbojet.

halflife—The average time required for one half the atoms in a radioactive element to decay.

hard gamma—A high-energy gamma capable of deep penetration in dense material.

heat sink—A radiator or condenser, that is designed to absorb the excess heat energy of the working fluid. Also called heat dump.

hot and cold junctions—The ends of a thermocouple, one being heated and one not heated. The difference in temperature at the ends creates an electric-potential difference along the thermocouple, allowing electrons to flow from one end to the other.

hot "crits" — Critical-reactor experiments to prove out theoretical reactor designs.

hot shop—A building in which the components of a nuclear reactor or other irradiated device can be disassembled and reassembled. The work is done remotely from behind shielded walls, usually thick concrete.

– I –

ITS—Idaho Test Station, a section of AEC's National Reactor Test Station provided to GE-ANPD for the heat-transfer reactor experiments.

integrated flux (nvt)—The total number of neutrons per unit area that interact with particles constituting the sample.

intermetallic compound—An alloy of two metals in a solid phase which is characterized by hardness, brittleness, and limited solubility with the other phases present. The compound, which is held together by metallic bonding,

ATOMIC VOCABULARY

continued

forms a complicated crystal structure.

ion—An atom or group of atoms not electrically neutral.

ionizing radiation — Radiation which ionizes the material through which it passes.

irradiation—The process of subjecting a material to a radiation flux.

isotopes—Atoms of the same element but of different atomic mass. Atoms of an element in which the nuclei contain the same number of protons but different numbers of neutrons.

– K – L –

kev—Thousand electron volts.

Kiwi-A—The first reactor developed under the Rover (nuclear-powered rocket) project. It operates on an open cycle where the propellant (hydrogen gas) heated in the reactor core is expanded through a nozzle to the atmosphere. This reactor was not intended for flight.

kwe—Kilowatts of electrical energy.

LAROO—Lockheed Aircraft Reactors Operations Office at Evendale, Ohio.

LASL—Los Alamos Scientific Laboratory, owned by AEC, located at Los Alamos, New Mexico, and operated under contract by the University of California. Rover (nuclear-powered rocket) reactor work is under its direction.

LRL — Lawrence Radiation Laboratory, owned by AEC, located at Livermore, Calif., and operated under contract by the University of California. Pluto (nuclear-powered ramjet) reactor work is under its direction.

lapse — Meterological condition of a decreasing air temperature with increase in altitude.

lattice—A geometric pattern, in which fuel and moderator are interspersed in a heterogeneous reactor. The pattern of negative and positive ions held together by electrostatic forces. The normal arrangement of atoms in a molecule.

leakage—Loss of neutrons by outward diffusion from a reactor core.

– M –

mass ratio—The ratio between the initial mass of a rocket (takeoff mass) and the final mass of the vehicle or payload (burn-out weight) after power is exhausted or cut off.

MPE—Maximum Permissible Exposure. A radiation dose which is thought to cause no appreciable biological damage in humans, usually accepted as 25 rem.

metallic fuels—Fuels which are a mixture, a pressed powder, or an alloy of a fissionable material, e.g., uranium-235, plutonium 239, and a metal, such as aluminum, nichrome, or stainless steel.

Mev—Million electron volts. See electron Volt.

moderator—A material that has a high cross section for slowing down fast neutrons, with a minimum of absorption (heavy water or beryllium).

– N –

NARF — Nuclear Aircraft Research Facility, funded by the Air Force and operated by Convair at Ft. Worth, Texas.

NEPA—Nuclear Energy for the Propulsion of Aircraft. The first study project initiated to explore feasibility of nuclear-powered aircraft, undertaken for Air Force by the Fairchild Engine and Airplane Corporation at Oak Ridge National Laboratory in May 1946.

NERVA — Nuclear Environment Rocket Vehicle Application. Joint NASA-AEC project to provide a logical powerplant and early vehicle configuration from the Rover studies.

NETF — Nuclear Engineering Test Facility. A nuclear radiation facility being built by the Air Force at Wright Air Development Division.

NRTS—National Reactor Test Station. AEC's nuclear testing facility near Arco, Idaho.

NTA—Nuclear Test Aircraft. A modified B-36 that flew on conventional engines but which was equipped with a shielded crew compartment, nuclear instrumentation, and a reactor (the Aircraft Shield Test Reactor).

NTS—Nevada Test Site. AEC's facility near Las Vegas for testing weapons and propulsion reactors.

nucleus — The core of the atom in which most of the mass is concentrated.

nuclide—Any species of atom that exists for a measurable length of time and has a nuclear structure distinct from that of ony other species of atom.

– P –

pair production—The creation of a positron and an electron, usually called an electron pair, from the annihilation of a gamma-ray photon, as in the strong electric field near an atomic nucleus.

particles—Mass or energy particles that are "elementary" to the atom or are the observed products of subatomic reaction. Mass particles regarded as constituents of the atom include the neutron n, the electron e, and the proton p. Among the particles emitted from reaction are the positron $e+$, the photon γ as a quantum of radiated energy, and the alpha (α) and beta (β) nuclear "fragments."

photons — Electromagnetic waves, which are propagated through space in definite bundles of energy, or quanta, and that exhibit characteristics of both wave and particle.

plasma—A neutrally charged gas in which the ionization potential of the gas atoms has been exceeded. Each atom is thus allowed to separate into a positively charged ion and an electron.

Pluto project — AEC's experimental program established in 1956 to design, build, and test experimental reactors that will demonstrate feasibility of applying nuclear energy to a ramjet engine for missile propulsion. AEC has responsibility for reactor design and development, and the Air Force has development responsibility for the nonnuclear components of the ramjet engine. Technical work is centered at the Lawrence Radiation Laboratory.

poison—Those atoms (of such elements as boron) that have large capture cross sections for thermal neutrons. In capturing thermal neutrons unproductively, these atoms decrease the number available to cause fission.

positron—A particle equal in mass to an electron and bearing an equal but positive electrical charge.

power density—The rated power of a reactor or isotopic power source per unit weight of the fuel-bearing material, e.g., kilowatt-hours per pound or gram.

Project Orion—An ARPA-sponsored space program to launch a space station, with propulsion coming from a series of controlled atomic explosions. Feasibility studies are now under way at Convair Div. General Dynamics.

proton—An atomic particle of positive charge equal to the negative charge of the electron but of 1837 times the mass.

– R –

REIC—Radiation Effects Information Center established by the Air Force in May 1957 at the Battelle Memorial Institute, Columbus, Ohio.

RIFT—Reactor In Flight Testing, a lightly funded program to determine best configuration of a flight reactor for a nuclear rocket.

radiation — The emission of energy quanta in the form of waves through space or a material medium. Not only electromagnetic radiation but also streams of subatomic particles (alpha rays, beta rays) and the emitted subatomic particles themselves.

radiation dose—The amount of radiation absorbed by a material system, or tissue in a given amount of time.

radiation syndrome—Symptoms which occur in man as a result of radiation.

radioactive particulates—Minute radioactive particles.

radioactivity—The process in which nuclei of certain elements undergo spontaneous disintegration, accompanied by corpuscular or electromagnetic emanations (radiation).

radioisotope — A radioactive isotope that decays in a predictable decay scheme.

radionuclide—A radioactive nuclide.

Rankine cycle—An idealized thermodynamic cycle consisting of two constant-pressure processes and two isentropic processes. The principle appears in boiling a cycle fluid with isotope heat and driving a turbine generator by the expansion of the resulting vapor through a nozzle.

rare earths—The 15 metallic elements of atomic numbers 57 through 71 having such similar chemical properties that they are considered to occupy the position of a single element in Group III of the chemical periodic table.

reactor core—The central portion of a nuclear reactor, exclusive of the reflector and shields, containing the fissionable material and the moderator.

reflector—A material of high scattering cross section that surrounds a reactor core to reduce the escape of neutrons.

reflected core—A reactor core surrounded by a reflector that throws back into the core a percentage of the escaping neutrons.

rem—Roentgen-equivalent-man — A dose equal to that quantity of radiation which, when absorbed by a human being, produces the same effect as the absorption of one roentgen of high-voltage X rays.

rep — Roentgen-equivalent-physical —A proposed unit of an ionizing radiation dosage. Generally defined as a dose that induces energy absorption of 93 ergs per gram of tissue. Used extensively for the specification of permissible doses of ionizing radiations other than X rays or gamma rays.

r/hr—Roentgen per hour.

roentgen—A unit of radiation of X rays or gamma rays, that produces one electrostatic unit in a cubic centimeter of dry air under standard condition of temperature and pressure.

Rover project—A joint AEC-NASA project established in 1955 to demonstrate the feasibility of applying nuclear energy to rocket propulsion. Technical work is centered at the Los Alamos Scientific Laboratory.

– S –

STAR — Space Thermionic Auxiliary Reactor. A General Electric project aimed at developing small electric reactors for space. Development centered in Pleasanton, Calif.

scattering—Change in direction of a particle because of a collision with another particle or nuclear system.

shadow shield—A shield, other than the reactor shield, that is placed between the radiation source and a specific area to be protected. Useful in space, it is less effective in the earth's atmosphere because air scattering deflects radiation around it.

Slam — Abbreviation for Supersonic Low-Altitude Missile. An ARDC project on which three aircraft contractors (Chance Vought, North American Aviation, Inc., and Convair) have worked on conceptual designs.

Snap—Abbreviation for Systems for Nuclear Auxiliary Power.

Snap program — A program established to develop systems for nuclear auxiliary power, low-power devices of light weight and long life that produce from a few watts to several kilowatts of electricity to operate as reliable, long-enduring power sources for instrument packages in satellites and space probes. Serves both Air Force and NASA needs.

specific heat—The ratio between the amount of heat that it takes to raise the temperature of a given substance one degree and that required to raise an equal mass of water one degree.
specific power—The energy delivered per pound of fuel in a reactor.

static conversion—Energy conversion in which no moving parts of equipment are utilized.

steady state — The stable operating condition of a reactor in which the neutron inventory remains constant.

stoichiometric ratio—A law of chemical composition whereby elements will only combine with each other in definite, established ratios which are whole numbers of each constituent element.

structure activation — Radioactivity induced in the structure of the aircraft in which the reactor is operated.

subcritical—The status of a reactor that has slipped below critical. If not regulated with control rods, the reactor will shut itself down on an exponential decrease.

supercritical—The status of a reactor that has proceeded past the critical point, generating one new fission per previous fission. If not contained with control rods, the reactor will run away.

– T –

TALANT — Thiokol, Allison, Linde, And Nuclear Dev. Corp. Team for conducting studies on the Rover Project and SR's 150, 182, and 199.

TSF—Tower Shield Facility, constructed at Oak Ridge, Tennessee to simulate aircraft-reactor radiation patterns during flight.

thermal mw-year—A power of one megawatt of thermal energy produced continuously for one year.

Tory II—A Lawrence Radiation Laboratory reactor experiment to demonstrate the feasibility of nuclear-ramjet propulsion and to verify materials, neutronics, and other design information.

– V –

Van Allen radiation belts—Two concentric, doughnut-shaped layers of radioactive particles surrounding the earth that were discovered and measured by the Explorer satellites and Pioneer space probes. The first belt is 2000 miles thick and begins at 1400 miles altitude; the second is 4000 miles thick and begins at 8000 miles altitude.

void fraction—The fraction of the frontal area of a reactor that is open to air flow. Also referred to as free-flow area.

working fluid—A fluid, such as air or a liquid metal, which is heated by the reactor and from which heat is removed by a device which converts the heat into some other form of energy.

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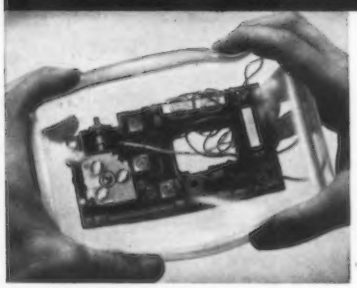
200 miles down the Atlantic Range, General Electric silicone rubber will help keep him afloat

Sixteen and a half minutes after its first manned launching, NASA's blunt-nosed Mercury spacecraft will paradrop into the Atlantic Ocean.

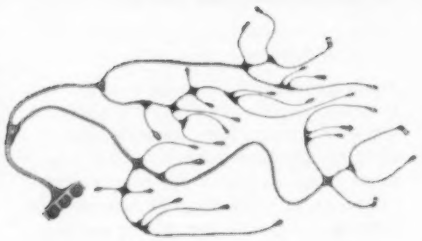
Here it will float like a buoy marker to await recovery. To help protect the first American astronaut, the Mercury spacecraft is completely sealed with General Electric RTV silicone rubber — the new liquid rubber designed to keep the spacecraft air and water tight even after being subjected to the temperature extremes encountered during take-off, flight and re-entry.

McDonnell Aircraft Corporation, prime contractor for the Mercury spacecraft, applies RTV around rivets and bolts wherever structural material, requiring sealing, overlaps or butts together. Able to cure at room temperature, versatile General Electric RTV silicone rubber has found a wide range of uses in missiles and ground support equipment.

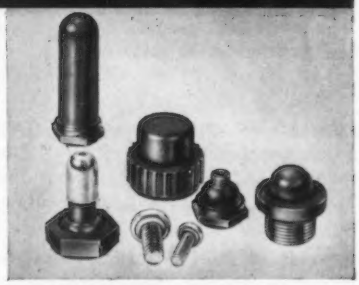
G-E SILICONE RUBBER FINDS MANY USES IN MISSILES AND SPACE VEHICLES



Potting and encapsulating materials protect delicate electronic parts. Clear LTV, shown above, is transparent even in sections several inches thick. RTV liquid silicone rubber encapsulants and clear LTV all exhibit excellent electrical properties, resist shock, vibration, ozone, plus corona and other environmental hazards.



Missile wiring harness, above, is from the Titan propulsion system. G-E silicone rubber wire insulation maintains good electrical properties over wide temperature extremes. Jacketing of high-strength silicone rubber, plus breakouts and junctions molded from RTV were chosen for their insulating properties, resistance to temperature extremes and stability in storage.



Silicone rubber gaskets and seals give long life, heat resistance, and low temperature flexibility in many missiles and space vehicles. Applications range from nose cone gaskets to tiny Seelskrews and Hexseals, by Automatic and Precision Mfg. Company, which combine fasteners with silicone rubber seals for easy assembly.

For full information on General Electric RTV silicone rubber, clear LTV silicone compound, and fabricated silicone rubber parts, write: General Electric Company, Silicone Products Dept., Section BB544, Waterford, New York.

GENERAL ELECTRIC

Cleanliness Slant on Reliability

Cleanliness measures practiced in modern "white rooms" would have made Pasteur envious. Indeed, the question "How clean is clean?" is now echoing with increasing regularity from many sectors of the aerospace industries.

The answer to this question will soon be furnished by the military. For, already taking shape is a specification which will draw the minimum requirements for white rooms. This will be a step by the government to gradually require component manufacturers to guarantee reliability to an extent heretofore thought impossible.

Anticipating the growing emphasis on cleanliness standards, the New Departure Div., General Motors Corp., recently equipped its Sandusky, Ohio, plant with an ultra-clean white room. In this silent, sterile room, glistening with stainless, are born the precision miniature bearings used in missile guidance systems.

The room provides a slanted-wall environment where "no dust can hide." Ventilation is introduced at the ceiling, with return grills close to the floor, to assure that any motion of air-borne contaminants will be down and out; the volume of air supplied to the room realizes 20 changes per hour.

Even though the environmental air is carefully controlled, all but a very small area of employes' faces are covered with man-made filament clothing. This is to control ejection of natural skin dust and garment lint. Air is taken from the room and two-stage filtered for a maximum particle, of three-tenths micron. This air is supplied to stainless steel "Steril-shield" work spaces

STILL, BRIGHT, AND SILENT white-room at New Departure Div., General Motors Corp., Sandusky, Ohio, has no vertical walls.

in which all work on the product, through assembly, functional testing and packaging is done. An evenly-distributed outward flow of this filtered air at 40 ft/min through the entire access opening of the Steril-shield is assured.

Except at door jambs and headers there are no perpendicular intersections of architectural surfaces. Ceiling and floor surfaces are coved into walls and partitions on sweeping radii. All vertical intersections are broken on 45 deg or "flatter" angles. Joints at panel and window junctions are closed with stainless steel battens having streamlined edges, thereby avoiding corners that might collect dust.

All vertical walls and partitions "lean" into the cleanest areas at approximately three degrees off-plumb. This deters adhesion of precipitating dust particles and deflects any glare reflected from the high illumination-level and the polished stainless surfaces.

Lighting at work level is maintained in excess of 200 foot candles, diffused through plastic prismatic lenses to eliminate glare. Light fixtures are above the lenses, which are sealed flush with the ceiling. Maintenance is done from above.

In the face of such meticulous measures, an obvious question pops in the mind of outside observers: Do the users of these ultra-clean bearings also accord them similar treatment while assembling them into the guidance systems? The terse answer from New Departure management is: "Some do; some don't." Those who don't, however, better be prepared for a rude awakening in the light of tightening reliability standards.

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S. 836...

More Monkey Business On The "Hill"

By Tom Mac New

Editor Mac New
". . . a non-controversial Bill?"

Does your company do business with the U. S. Government? Whether you sell airplanes, missiles or floor mops, you should have an interest in a little known bill that will make a significant change in subcontracting activities. In fact, the bill in its present form might even bring another federal agency into your purchasing and engineering departments.

This bill, S. 836 by Senator William Proxmire (Wisc.), is opposed in its present form by business, both large and small, and by the three principal agencies it would blend together into a mandatory subcontracting program for small business.

Here's how it happens. The bill specifically seeks to help small business in two seemingly innocuous ways: 1. by increasing the loan authority of the Small Business Administration; 2. by directing the SBA Administrator, in consultation with several other officials, to promulgate a new small business subcontracting program to insure that a larger share of the defense dollar goes to little firms.

This certainly sounds praiseworthy, but the Small Business Administration, in recent hearings held before the Senate Subcommittee on Small Business in Washington, indicated it was opposed to making the program mandatory. In fact, SBA said it favored a "cooperative" program.

The Department of Defense and the General Services Administration joined the SBA in its opposition to Section 8 in its present form which creates the subcontracting program. Many small businesses protested and larger firms are opposing the bill for several basic reasons.

One of the chief objections stems from the fact that the bill grants broad powers to the SBA to effect the program. It places only two limitations: (1) The SBA cannot tell a firm to whom it should subcontract; (2) It cannot tell how much to subcontract.

However, private industry can reasonably predict what the program would be, by analyzing the existing programs and reading the proposed law. Here is what industry might well expect: 1. "assistance" in the selection of prospective suppliers; 2. "advice" as to the method of proposal, vendor selection and type of contract; 3. qualification of suppliers by the SBA, apart from the contractors own reliability program; 4. additional administrative burdens by mandatory reporting on compliance with the program.

Large businesses have a responsibility to object on these grounds. The vagueness of the legislation leaves the program literally at the whim of someone in Washington who may never have seen a large or small business, or never have read a government contract.

Further, firms making defense products can ill afford to have another government agency projecting itself in the normal buyer-seller relationship. Most companies have built up long lists of responsible suppliers, mostly small businesses. They must have the authority to choose their own suppliers in order to protect the integrity of their equipment. In today's complex defense business, the failure of a 50-cent part can result in failure of a $1-million missile. It's a poor bargain for the taxpayers.

The Department of Defense made the same objection in its testimony before the Senate Committee. Said Defense Undersecretary Thomas D. Morris: "If a contractor acquiesced in an SBA recommendation on the choice of a subcontractor, and the subcontractor failed in performance, the entire procurement might be jeopardized. Certainly, costs to the Defense Department could be substantially increased."

Undersecretary Morris went on to note that DOD already has in effect a subcontracting program which contains certain features found in S. 836. Why, then, add another program on top? Let's see what the Defense Department's program can do before scrapping it.

Additionally, neither the small firms nor the larger ones want to

have to satisfy both the Department of Defense and the SBA. In the complexity of the procurement field, this could be an almost impossible task.

Since federal champions of small business refuse to believe that enough prime contract dollars are distributed to small business suppliers, they advocate this subcontracting program to control the procurement dollars as it trickles through every layer of our economy. What these champions would really ultimately want is unrestricted advertised bidding for parts. They are convinced that by this method they can force more defense dollars into the small business field, since the only consideration in advertised bidding is price.

Low Bidder Fallacy—The man with the lowest price gets the order. It doesn't mean he has the best product; it doesn't mean it will be reliable when it is put on the $1-million missile and it doesn't mean he stands behind it with hours of research and testing. It simply means he had the lowest price. This form of procurement may well solve the problem of giving a little more of the defense dollar to some small business, but it will not insure the safety of our nation in these perilous times.

Should this bill be adopted, and the Small Business Administration undertake execution of a subcontracting program, then the SBA representative is likely to show up soon to advise your purchasing agents and assist them in the areas mentioned before. Since in the awarding and reviewing of contracts, they will undoubtedly run into some technical areas, they could even wind up in your engineering department checking on details of the product.

The concept represented by S. 836 is not a new one and its history is as devious as the revolutionary control it wants to saddle on private industry.

Last year, Senator Proxmire took a Bill that had been passed by the House of Representatives (H. R. 11207) and sent to the Senate. This Bill also concerned the SBA, but its provisions were non-controversial. Senator Proxmire substituted the language of his own Bill, S. 3689, which contained the proposals for the Small Business Subcontracting program, for the House approved H.R. 11207.

Passed In a Rush—Just as Congress was packing its bags to hurry to Los Angeles for the Democratic Convention, Senator Proxmire brought the amended H.R. 11207 up for consideration, saying . . . "this is a non-controversial Bill and will not require much time for consideration." Well, it may have been non-controversial when it left the House, but not after Senator Proxmire made his amendments. However, the Senators took him at his word, passed the Bill and rushed to Los Angeles.

Subsequent protests from thousands of Small Businessmen indicated that the amendments were "controversial." The House of Representatives refused to buy the Senate version of their H.R. 11207, and it died in a Joint Conference Committee.

The vehement objections that this proposal raised last year show that the Congressional champions of Small Business are "without portfolio" when they advocate a mandatory Small Business Subcontracting program. Many small businesses object, as do the large companies who use their services.

The "cooperative" program recently urged by SBA to the Senate, with strong support from DOD and General Services Administration, has also won approval of large and small business. None of the agencies involved nor the business community is opposed in principle to the establishment of a program. This was clearly indicated in their testimony to the Senate Committee. But legislation like S. 836 with its mandatory authority can create many hardships, not to mention the immense new burden of administrative cost, all of which must ultimately be passed on to the government.

FACTS ON PROXMIRE BILL

S.836 introduced Feb. 9, 1961, by Senator William Proxmire (D-Wisc.); referred to Senate Banking & Currency Committee.

H.R. 5120, identical bill, introduced Mar. 1, 1961, by Rep. Abram J. Multer (D-NY); referred to House Banking & Currency Committee.

Bill is modified version of 1960 bill (H.R. 11207) as amended by Proxmire—originally passed by voice vote in Senate on claim it was "non-controversial" — later defeated (August, 1960) by narrow margin when Senate-House conferees failed to agree after nation-wide protests from small business.

Only 12-day notice given by Senator Proxmire in announcing March 3 (Friday) that hearings would be held March 15, 1961. Direct notice not sent to interested associations (e.g. Strategic Industries—small defense producers) who opposed bill in 1960.

For the bill: Most staff and members of Senate Small Business Committee, plus others in House and Senate who want to "do something" for small business.

Against: (1) Department of Defense, (2) House Armed Services Committee (Carl Vinson), (3) small businesses experienced in defense, (4) large businesses in defense.

Principal objections to Sec. 8 and 9; other sections of bill not objectionable.

Sec. 8. Would give Small Business Administration program authority over D.O.D., Atomic Energy and General Service Administration subcontracts. Extent of authority almost unlimited

Criticisms: SBA authority would be without responsibility. Need not demonstrated. D.O.D. presently has extensive subcontracting program. Dangers of delay to production and development from interference. SBA inexperienced in field. Vast growth of bureaucracy if SBA attempted to build staff with knowledge approaching present industry know-how. Against free enterprise to come between seller and buyer without responsibility to either.

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Miniaturize Space and Costs.... Use Microfilm

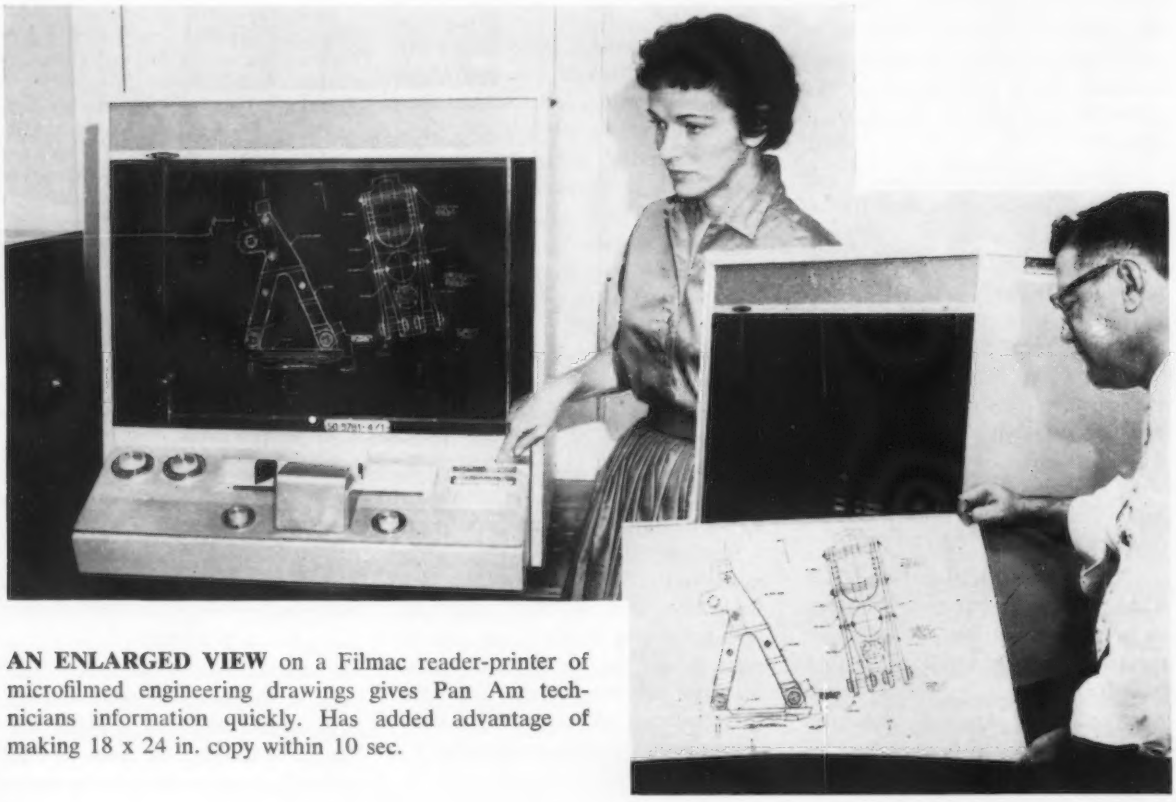
Boeing and Douglas supply tens of thousands of engineering drawings to Pan Am for 707 and DC-8

With the purchase of Boeing and Douglas commercial jets, Pan American received all of the engineering drawings from the makers. Both builders put everything on microfilm; Boeing used the Filmsort aperture card with Douglas using their own CIM card.

A prime reason for the microfilm approach was the enormous volume of the prints. In Pan Am's New York depot there are 50,000 drawings from Douglas and 25,000 from Boeing. Miami reports 30,000 from Douglas alone.

Pan Am figures the microfilm setup, used in conjunction with a Filmac reader-printer, has saved a lot of time and money. Instead of the task of poring over huge prints, engineering personnel can view a sharp image on a projection screen or make a copy of the section within 10 sec.

All microfilmed drawings and specs are keyed by number to master section documents, maintenance manuals, overhaul manuals, and service bulletins. Users are the standards engineering department, production control, engine overhaul shops, and component overhaul shops. ✦



AN ENLARGED VIEW on a Filmac reader-printer of microfilmed engineering drawings gives Pan Am technicians information quickly. Has added advantage of making 18 x 24 in. copy within 10 sec.

Navy Tells How It Saves Money

New sources sought constantly to expand competitive bidding; Increased competition results in savings of $1.6 million

An article in a recent issue of a leading magazine read—"We have been long in the business of extracting, shaping, fitting, and — when time permitted—polishing words." The point is that industrial leaders and technologists have been giving increased attention to "communications." The article goes on to state that an innovation being considered —dropping unnecessary words as in a telegram—when writing company interoffice mail — could improve communication efficiency five per cent.

Whether or not this would prove to be so, the idea remains that unless you try for more, your efforts may produce stagnant results. At least, this is what the U. S. Navy Aviation Supply Office (ASO), Philadelphia, Pa., thinks when it comes to showing improvement in its buying practices and techniques.

ASO has been extracting, shaping and fitting its "words" and works in developing improvements to effect a higher efficiency of the taxpayers' defense dollars producing equipment and supplies to the end that the results will depict without much question that this office does a good job of buying.

How so? Well, let's make a long story short!

Congress provides the money. How much did "Small Business" get? How much did you buy through negotiated contracts and how much did you spend as the result of competitive bids? How much have you saved as the result of competitive contracts where you previously bought the same things from other fellows all the time? How . . . what . . .

Many people do business with the Navy but few know very much about who shapes the words, what runs the works, etc. The Congress is closer to this than a lot of those "many people" doing business with the Navy—and even the Congress doesn't know—until they ask the questions. And what questions!!! If you, Mr. Businessman, think it's tough to make money, you have some idea how difficult it is to get the Congress to "give" so the Navy can support its end of the Defense picture!

Well, maybe it's not as tough as it used to be. Why? Because the Navy is doing better and the Congress knows it.

The short-story is that the Navy has been saving a lot of money and at the same time has been doing better as far as the small businessman goes.

How? For example, in 1959 fiscal year, the Aviation Supply Office spent over $550,000,000 of which about 10 per cent went to small business. During the 1960 fiscal year, ASO approached the 15 per cent figure for small business and that's a 50 per cent improvement. That's part of the short story.

Seeking New Sources — The Navy has found that other companies can meet the specifications and deliver the same things and many times they are big business and many other times they are small business firms. ASO has been most successful in developing new sources —some who have been sub-contractors and are now interested in becoming "Primes." This is done by shaping or polishing the words—or determining that the data the Navy has is sufficient for another manufacturer to use—in order to secure the same items of equipment.

What about saving money? Well, as a result of getting new sources the ASO obtains more competitive bids, and it develops naturally that they buy what they need for fewer dollars — thereby saving money which otherwise would have been needed to buy the same items as preceding procurements. The net result is that where ASO previously had to cut out items or partial quantities from the "Shopping Lists" they now can also buy some of those items and required quantities. Accordingly, the efficiency of the Taxpayers' Defense Dollars is improved and the Navy does a much better job. This info is reported regularly to Congress. ASO, alone, has saved in excess of $1,600,000 in a single year.

The Visible Results — Specifically, to cite a few cases, the Navy has realized such savings as $22,172 on 21 items of propeller parts and tools; $6,372 on one item of ladders used in refueling aircraft; and $175,330 on one item of trailers for rail handling of aircraft and missile sections. This is a continuing program and while it was expected that the items bought competitively for the first time would gradually diminish, the number of items being bought competitively has been increasing.

ASO expects to keep on polishing the words or shaping the works or whatever is necessary to help Small Business and at the same time spend the taxpayers' money, received from Congress, with the highest degree of efficiency practicable.

SEE NEXT PAGE

Industry Tells
How Navy "Wastes" Money

Industry Tells How Navy "Wastes" Money

Penny-wise, pound-foolish policy claimed in spare part procurement; Obsolete, incomplete data often accompanies requests for bids

The military can often be heard lauding its own cost consciousness. The Congress can often be heard attacking waste in military procurement. And industry can often be heard claiming low profits, confiscatory procurement practices, and the need for higher defense expenditures. Wherein lies the truth?

Events which took place during a recent small procurement at ASO Philadelphia (the same office extolling its virtues on the opposite page) show that such agencies do in fact try to save money, but engage in dealings which border on the non-ethical while attempting to effect the savings. In the end, more money is spent than is "saved".

Advertised bids, multiple source selection and the resultant competition are what all voices seem in harmony about. Surely industry and Congress have spoken long and hard about the virtues of giving all logical contenders a shot at the contract prize. The military in most cases is happy to oblige. But the methods it uses in going about this often spoil the results of their best intentions. Sending one company's prints to another company is a common practice. But the fraternal ethics of the industry is surprisingly strong. One company is not extremely proud that it is obtaining another company's prints to examine and under bid. Companies are banding together often refusing to take part in such clandestine negotiations.

Refusal to Bid—Late last year Navy decided it needed some spare helicopter rotor parts for HTL-7 and HUL-1. The parts were orginally manufactured by Bell. Thinking it might save a few dollars, build up another supplier, and kept the Congress happy, ASO Philadelphia decided to buy the spares under an advertised bid.

IFB- 383-243-61 was sent to all companies with a known capability for adhesive bonding of rotor components. Bell's original drawing accompanied the invitation. About a month passed. Navy received only two responses, Bell and Doman. Why? One company who refused to bid put it this way, "It is interesting to note that the drawings which accompanied the request for bid were dated 1955. In a dynamic industry such as this, drawings and material and process specs five years old are certainly out of date. In this case the bonding agent called-out is one long since found lacking in low temperature strength. Bell switched to a different adhesive system years ago. Now, the part on which we were to bid is vital to the integrity of the rotor blade. It follows then that it is vital also to the helicopter and its occupants. This sort of penny-wise pound-foolishness in government procurement practices is case for grave concern."

Contest Without A Winner—The Navy then set out to pick a winner from its competition. But it was disappointed. The Doman bid had been submitted in error. The parts were to be manufactured by lamination and Doman had not reckoned with this. The Bell bid was judged "non-responsive" because Bell and Navy could not come to terms on all of the stipulations of IFB.

Navy now found itself in the embarrassing position of having held a contest and eliminated all of the contestants. There was no winner, so Navy could not award the prize. But the parts were needed. How to get them? There seemed no way out but to the negotiated contract. But with whom could Navy negotiate? Doman? No, they could not manufacture the part to laminated specs. Some other helicopter company? No, none was interested in tooling up for such a small procurement. Who was left? Why Bell, of course. The company whose helicopter would use the parts. The company whose prints provided the only real bid information; the only company equipped to do the job in the first place. So Navy ASO **negotiated** a contract with Bell. The amount of the procurement? A rather insignificant $9,000.

How much did ASO save on this transaction? Paper work, secretaries' fees, buyers' salaries, and costs incurred by bid evaluators in industry probably amounted to as much as the total procurement after all of the shadow boxing. Also, think of time lost. The fancy footwork before the ultimate negotiated contract turned out to be a waste.

A shame that so much nonsense is perpetrated in the name of economy. Yet, it happens every day. Advertised bids may be desirable, but not if they can be obtained only by passing a company's prints around to "competitors". It is everyone's intention to save a little money. But in complicated military procurement, intentions are not enough.

◆

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Prototype model of a high pressure, high torque rotary actuator will be displayed. — *Carter Controls Inc.*

Circle 61 on Inquiry Card for more data

Tapered Tubing

Tapered tubing, which is being used in thrust chambers and finned tubing for nuclear applications will be featured. — *Superior Tube Co. Booth No. 849*

Circle 62 on Inquiry Card for more data

Ball Bushing

New die set ball bushing allows substitution of anti-friction linear bearings for friction type sleeve bearing in die sets.—*Thomson Industries, Inc. Booth 962*

Circle 63 on Inquiry Card for more data

Small Parts Designs

The use of high speed, automatic die casting and plastic molding techniques to improve small parts design will be featured.—*Gries Reproducer Corp. Booth No. 1143*

Circle 64 on Inquiry Card for more data

Cast Stainless

Castings will be displayed illustrating reduced fabrication costs and improved performance.—*Alloy Casting Institute. Booth No. 329*

Circle 65 on Inquiry Card for more data

Beryllium Heat Sinks

Transistorized dielectric heat sinks' availability announced. — *National Beryllia Corp.*

Circle 66 on Inquiry Card for more data

Hi Temp Ceramic Balls

Display will include balls of delrin, lexan, nylon and teflon with special bearings for corrosive and extreme temp applications.—*Industrial Tectonics, Inc. Booth No. 1000*

Circle 67 on Inquiry Card for more data

Vibrators

Hand held "Little Giant" and "Big Shake" vibrator which offers up to four tons "Centriforce" will be displayed. — *Martin Engineering Co. Booth No. 138*

Circle 68 on Inquiry Card for more data

Aviation Clamps

Brochure on stainless steel "quick latch" and t-bolt clamps. — *Wittek Mfg. Co.*

Circle 69 on Inquiry Card for more data

Alloy Steel Bars

Information on the machining qualities of high strength alloy steel bars.—*La Salle Steel Co. Booth No. 563*

Circle 70 on Inquiry Card for more data

Panel Fastener

New access panel fastener, when disengaged, automatically pops into fully retracted position. — *Southco Div., South Chester Corp. Booth No. 1021*

Circle 71 on Inquiry Card for more data

Air Cylinders

Miniature air cylinders for activating electrical contacts in test jigs and fixtures, as miniature air vices and in automatic work for feeding, ejecting, etc.—*Airmatic Valve, Inc.*

Circle 72 on Inquiry Card for more data

Lip Seal Inspection

Machine can automatically inspect 700 lip seals an hour for diameter, pressure and eccentricity.—*Research Laboratories, General Motors Corp.*

Circle 73 on Inquiry Card for more data

Coiled Cords

New line of retractile coiled cords and molded on components.—*Miller Electric Co.*

Circle 74 on Inquiry Card for more data

Self-Stickers

Self-bonding nameplates, wire markers, automatic marking machines and tapes.—*W. H. Brady Co. Booth No. 321*

Circle 75 on Inquiry Card for more data

Chain Drives

Chain drives for transmitting power of small gas turbine engines (30 to 1800 hp). Applicable to main or auxiliary drives. This new chain is refinement of the silent chain principle for high speeds.—*Morse Chain Co.*

Circle 76 on Inquiry Card for more data

Intricate Castings

Process for casting which produces dense, structurally sound castings from virtually all castable alloys.—*Foundry Div., Waukesha Foundry Co. Booth No. 616*

Circle 77 on Inquiry Card for more data

Poppet Check Valve

New poppet check valve features turbulence rings to provide stability. —*Nuclear Products Co.*

Circle 78 on Inquiry Card for more data

Tin Alloy

Samples of tin-titanium-aluminum alloy used for the housing of jet engines on such aircraft as the B-58.—*Malayan Tin Bureau. Booth No. 1047*

Circle 79 on Inquiry Card for more data

Flexible Tubing

Line of metal hose and flexible tubing assemblies, includes metal-plastic combinations. — *Anaconda Metal Hose Div. Booth No. 312*

Circle 80 on Inquiry Card for more data

Solid State Timing

New line of solid state timing units uses printed circuits throughout. Units are potted and hermetically sealed. — *Agastat Timing Instruments*

Circle 81 on Inquiry Card for more data

Coordinate Drawing Machines

Ultra-precise drafting instruments will be featured. — *Unitech Corp. Booth No. 1127*

Circle 82 on Inquiry Card for more data

Control Panel Wiring

Panel chanel wiring raceways with preformed corners and T connections eliminate much handwork. Bundling and lacing are unnecessary and all wires are easily accessible for final checkout.—*Stahlin Brothers, Inc.*

Circle 83 on Inquiry Card for more data

Electronic Rack Cabinet

Standardized electronic rack cabinet of heavy duty construction for heavy loads provides stable anchoring points for components.—*Falstrom Co.*

Circle 84 on Inquiry Card for more data

Glass Fabric Epoxy

New NEMA G-10 glass fabric epoxy laminate has following advantages: flame retardancy, superior cold-punching, increased solvent resistance. — *Continental - Diamond Fibre Corp.*

Circle 85 on Inquiry Card for more data

Tapping Screw

Hole-drilling tapping screw eliminates hole punching or drilling of light gage sheet metal. Screw not only drills its own hole and forms its own thread, but has an integral washer with serrated face.—*Parker-Kalon. Booth No. 451*

Circle 86 on Inquiry Card for more data

D. E. Show... cont.

Socket Screws

Line of multiple spline and hex socket screws as well as Nylok socket screws will be displayed.—*The Bristol Co. Booth No. 1036*

Circle 87 on Inquiry Card for more data

Bearings

Precision standard and special ball and roller bearings; needle bearings, needle rollers; and thin section, large bore bearings.—*Kaydon Engineering Corp. Booth No. 137*

Circle 88 on Inquiry Card for more data

Gears

Line of crown-ground case hardened spur and helical gears.—*Sier-Bath Gear & Pump Co. Booth No. 958*

Circle 89 on Inquiry Card for more data

Revolving Joints

New type revolving joint is capable of handling 500 lb air or hydraulic pressure with a minimum of turning torque at speeds around 1500 rpm.—*Rotherm Engineering Co.*

Circle 90 on Inquiry Card for more data

Adapter Materials

Exhibit will compare relative behavior of homogeneous rubber, fabric, metal and phenolic as adapter materials. Complete line of rod and cylinder packings, and compatible fire-resistant hydraulic fluids will be shown.—*E. F. Houghton & Co. Booth No. 920*

Circle 91 on Inquiry Card for more data

Pump/Motor Unit

New integral pump and motor unit is capable of producing vacuums to 27" Hg or pressure to 15 psig.—*Leiman Bros., Inc.*

Circle 92 on Inquiry Card for more data

Rod Packing

New type of hydraulic or pneumatic rod packing.—*Greene, Tweed & Co.*

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Remote Temp Control

Adjustable control for liquids, solids and gases will control temperatures in two standard ranges, from 0 deg F to 450 deg F, or from 450 deg F to 800 deg F.—*Electro-Flex Heat Inc. Booth No. 112*

Circle 94 on Inquiry Card for more data

Hi Fatigue Fasteners

New series of standard high-fatigue tension fasteners for critical high-strength applications.—*Standard Pressed Steel Co.*

Circle 95 on Inquiry Card for more data

Ground Support Bearings

Complete line of bearings for aircraft and missile industries.—*Chain Belt Co.*

Circle 96 on Inquiry Card for more data

Silicol Components

Custom compounding and molding of components for extreme temperature applications.—*Colonial Rubber Co. Booth No. 919*

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Universal Joints

New line of universal joints handles speeds up to 1500 rpm available in single and double joints.—*Lovejoy Flexible Coupling Co.*

Circle 98 on Inquiry Card for more data

90 Deg Gear Box

New box for making sharp bends in rotary-type remote control linkages.—*Stow Mfg. Co.*

Circle 99 on Inquiry Card for more data

Solderless Terminals

New line of large size solderless electrical terminals and connectors.—*ETC Inc. Booth No. 1157*

Circle 100 on Inquiry Card for more data

Strain Relief Bushings

Nylon strain relief bushings for insulating and anchoring power supply cords, cable and harnesses through panels or chassis.—*Heyman Mfg. Co.*

Circle 101 on Inquiry Card for more data

Self-locking Fasteners

New miniature floating clinch nuts will be featured.—*Elastic Stop Nut Corp. Booths No. 720 and No. 726*

Circle 102 on Inquiry Card for more data

Vacuum Investment-casting

Blades and wheels made by vacuum investment-casting of vacuum melted alloys will be displayed.—*Haynes Stellite Co. Div. of Union Carbide Corp. Booth No. 643*

Circle 103 on Inquiry Card for more data

Two-stage Pump

New two-stage hydraulic pump delivers from 600 cu in/min at 100 psi to 50 cu in/min at 10,000 psi and weighs only 45 lbs.—*Precision Hydraulics Div., Owatonna Tool Co. Booth No. 1203*

Circle 104 on Inquiry Card for more data

Aluminum Connectors

New cold-forged aluminum connectors for aluminum aircraft cable. *The Thomas & Betts Co.*

Circle 105 on Inquiry Card for more data

Film Technology

Engineering materials ranging from the "Echo" skin to printed circuitry will be displayed along with new cementable type Teflon film.—*Du Pont Film Dept. Booth No. 860.*

Circle 106 on Inquiry Card for more data

Nylon Castings

Introduction of a nylon casting service for production of high viscosity nylon castings weighing up to 6 lbs.—*Nylon Molded Products Corp. Booth No. 125.*

Circle 107 on Inquiry Card for more data

Variable Speed Drives

New P.I.V. (positive infinitely variable) speed drive designed with ratings up to 50 hp will be displayed with line of power transmission equipment.—*Link-Belt Co. Booth No. 743.*

Circle 108 on Inquiry Card for more data

Centrifugal Castings

Display will feature centrifugal castings from various ferrous and non-ferrous alloys as well as powder spray and weld hard facing. *Janney Cylinder Co. Booth No. 1163.*

Circle 109 on Inquiry Card for more data

Epoxy Products

Applications of epoxies and assemblies using various adhesives, plastic alloys, sealants and coatings will be featured.—*H. B. Fuller Co. Booth No. 1129.*

Circle 110 on Inquiry Card for more data

Vacuum Casting

Display will feature full scale cutaway of a gas turbine engine and rocket nozzles to illustrate products made by vacuum investment-casting of vacuum melted alloys and hot pressing of pure tungsten.—*Haynes Stellite Co. Booth No. 643.*

Circle 111 on Inquiry Card for more data

Hi Temp Alloys

Exhibit will include bars, special shapes, rings, bushings, etc., of stainless steel, hi temp alloys and will include exotic alloys.—*Space Missile Materials Corp. Booth No. 1256.*

Circle 112 on Inquiry Card for more data

Spraywelder

New medium capacity spraywelder for hard-surfacing or flame spraying will be displayed with two new experimental hard-surfacing alloys.—*Wall Colmonoy Corp. Booth No. 1234*

Circle 113 on Inquiry Card for more data

Ballistic Flarer

Device makes it possible to flare heavy wall stainless steel tubing.—*Parker Fitting & Hose Div., Parker-Hannifin Corp.*

Circle 114 on Inquiry Card for more data

Midget Bearings

Permanently lubricated, self-aligning midget bearing cartridges in sizes ranging from one-eight to five-eighths.—*Randall Graphite Bearings Inc.*

Circle 115 on Inquiry Card for more data

Wire Marking

New systems of marking wire with self-laminating wire markers.—*Westling Products Div., Western Lithographing Co.*

Circle 116 on Inquiry Card for more data

Adhesives

New structural adhesives, contact bond adhesives and printed circuit adhesives will be featured.—*Adhesives, Coatings and Sealers Div., Minnesota Mining and Mfg. Co. Booth No. 560*

Circle 117 on Inquiry Card for more data

Antifriction Bearing

A model of the antifriction bearing screw illustrating the basic free wheeling and positive drive characteristics will be displayed.—*Roton Products Div., The Anderson Co. Booth No. 800*

Circle 118 on Inquiry Card for more data

Oilless Bearing Material

Material is being used on universal joints of drive shafts for auxiliary jet engines and on airborne computers.—*Arguto Oilless Bearing Co.*

Circle 119 on Inquiry Card for more data

Self-Sealing Coupling

New coupling for use in aircraft fuel, oil, low pressure hydraulic, pneumatic and other systems.—*Aeroquip Corp. Booths No. 19 and No. 718*

Circle 120 on Inquiry Card for more data

Product Searcher

System for products searching in aerospace and electronic industries permits engineers and purchasing agents to locate technical data in minutes. Called VSMF, Microfilm Catalog File system.—*Information Handling Services, Inc.*

Circle 121 on Inquiry Card for more data

Chassis Latch

Electronic chassis latches, quick release pins and flush latches will be exhibited.—*The Hartwell Corp.*

Circle 122 on Inquiry Card for more data

Momentary Contact Switch

New 30 amp momentary contact switch series.—*McGill Mfg. Co. Booths No. 1031 and No. 1037*

Circle 123 on Inquiry Card for more data

Ceramoplastic

New precision-moldable insulation material offers improved hi temp performance. Insulation operates at temperature to 1200 deg F.—*Mycalex Corp. of America. Booth No. 1063*

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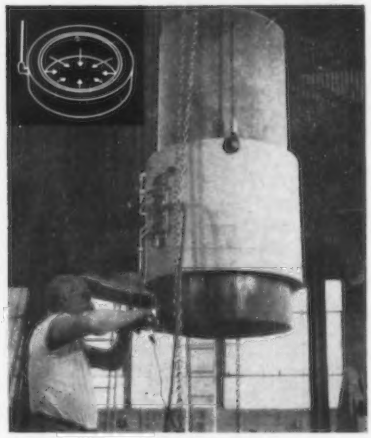

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Men on the Move

FRANCIS H. BOLAND JR. elected V. P. of ACF Industries, Inc. and appointed general manager of the American Car and Foundry division. CHARLES F. VENRICK appointed director of marketing for this division. GEORGE B. SHAW, head of ACF Electronics division, elected V. P. of the corporation.

R. J. ARMITAGE named director of logistics for North American Aviation's Space and Information Systems Div. Other appointments include: K. B. GAY, director of material; WILLIAM W. BAKER, controller; and FRANK G. COMPTON, plans and marketing director.

R. JAMES YARNELL promoted to Manager-Advertising and JAMES R. GREENWOOD named Manager-Press Relations by Beech Aircraft Corp.

WALTER B. BREWER, JR., appointed Assistant General Manager of Aerospace Corp.'s Engineering Div.

W. W. RUTLEDGE named operations manager by Boeing Industrial Products Div.

DR. CHARLES E. WARING appointed assistant technical director and head of research, U. S. Naval Ordnance Test Station at China Lake.

JOSEPH H. FAMME named assistant division manager-operations for Convair's San Diego Div.

B. E. STITT named assistant chief project engineer-Nike systems and DR. WARREN N. ARNQUIST appointed assistant to director of advanced research for the Douglas Aircraft Co.

BURL H. ERVIN named applications engineerings director for Systems Support Dept. and STANLEY W. CALL assumes identical position for Electronic Systems and Equipment Dept. of Northrop's Nortronics Div.

RUDOLPH V. COMTOIS joined Conductorlab, Inc. as V. P. and Chief Engineer, and WARREN G. ABBOTT named sales manager.

JAMES A. LIONTAS appointed manager-field engineering for the Analytical & Control Div., Consolidated Electrodynamics Corp.

JOHN R. BAKER appointed director of planning for MB Electronics.

GILBERT O. KINDT named manager of testing for Stellardyne Laboratories, Inc.

W. L. DUVAL appointed assistant chief engineer for missile and space field operations by Douglas Aircraft Co.

WILLIAM K. FORTMAN named director of project engineering for Astrosonics, Inc.

MYRON C. POGUE appointed manager of planning for Western Development Laboratories of Philco Corp.

DR. MARVIN CHESTER joined technical staff of Electro-Optical Systems Inc.

EDGAR M. SHURTLEFF named director of R. & D. by Special Devices Inc.

ARTHUR G. ALEN appointed chief engineer of The Matthews Corp.

RICHARD D. MORONEY named project engineer for G. T. Schjeldahl Company's stratospheric balloon and high altitude research programs.

EDWARD D. WEISERT joined research dept. at Rocketdyne division of North American Aviation, Inc. M. M. HENRY appointed assistant to the president of the Space and Information Systems Div.

A. N. KAUFMAN elevated to vice president-manufacturing and H. M. HENDERSON named vice president-sales by Arnolt Corp.

RICHARD J. MARTIN named engineer to head evaluation and tests at Magne-Head Div., General Instrument Corp.

BOYCE ADAMS named sales manager for Omnitronics, Inc., subsidiary of Borg-Warner Corp.

Warren Abbott
Conductorlab

Rudolph Comtois
Conductorlab

Boyce Adams
Omnitronics

Richard Martin
Magne-Head

Robert Lynch
McCormick Selph

Dr. Louis B. Werner
Hazleton-Nuclear

Thomas Vaughan
Antenna Systems

John M. Perkins
Astrosonics

Thomas Tatham
Ryan

Omer Hamann
Ryan

ROBERT W. LYNCH appointed chief engineer for McCormick Selph Associates.

THOMAS VAUGHAN joined Antenna Systems, Inc. as manager of RF Engineering.

WILLIAM M. SMITH appointed V. P. and manager of Bell Aerosystems Company's Aerospace Rockets Div. and FRANK H. ANDRIX named assistant V. P. and director of engineering for the Avionics Div.

DR. JOHN A. F. GERRARD appointed director of electronics engineering for Bendix-Pacific Div.

DR. DANIEL BINDER to head Hughes Aircraft Company's nuclear measurements department.

DR. LEONARD G. ABRAHAM, JR. named as engineering specialist at the Applied Research Laboratory of Sylvania Electric Products Inc.

ED. C. NIKKEL appointed weapon system manager—B-70 alert pod program for Beech Aircraft Corp. and T. L. MALTBY named weapon system manager — supersonic missile target system.

DR. PHILIP M. BRUNSTETTER appointed Director, management development programs at Aerojet-General Corp.

ROBERT L. LOWRY named manager of Avionics sales for Goodyear Aircraft Corp.

GEORGE E. HOLMES placed in charge of SUBROC and rocket production planning and control. HENRY H. NETTLING assigned responsibility for planning and processing functions for Goodyear Aircraft Corporation's SUBROC Div.

ARNOLD L. RUSTAY elected vice president of Wyman-Gordon Co.

PAUL F. WAIVERS appointed director of the environmental devices dev., United Aero Products Corp.

ROBERT C. LAUDENSLAGER advanced to senior project designer for Actuation Research Corp.

CAMILLE M. SHAAR, JR. named head of Aerospace Operations, Defense Systems Div., General Motors Corp.

ROGER L. SISSON appointed manager, program analysis, technical staff, Ford Motor Company's Aeronutronic Division.

DR. LOUIS B. WERNER named V. P. by Hazleton-Nuclear Science Corp.

JOHN M. PERKINS elected president of Astrosonics, Inc.

THOMAS H. TATHAM appointed Product Engineering Chief, OMER F. HAMANN appointed Chief of Applied Research at Ryan Transdata Inc.

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Worth Asking For

Ground Support Systems

Brochure portrays research, engineering and production facilities for magnetic recording and ground support systems.—*Magnasync Corp.*

Circle 125 on Inquiry Card for more data

Hi Temp Alloy

Revised booklet on MULTIMET alloy contains new information on resistance welding.—*Haynes Stellite Co.*

Circle 126 on Inquiry Card for more data

Computer Technology

"New Solutions in the Science of Simulation," illustrated brochure details the latest advances in computer technology and equipment. — *Computer Systems, Inc.*

Circle 127 on Inquiry Card for more data

CO_2 Sensor

Brochure describes glass electrode carbon dioxide sensor for use in closed cycle rebreathing systems.—*Beckman Instruments, Inc.*

Circle 128 on Inquiry Card for more data

Computer Consultants

Brochure on services in systems engineering, logic design, circuit design, and computer programming.—*MS & A, Inc.*

Circle 129 on Inquiry Card for more data

Aluminum Hard-Coating

Engineering report describes hard-anodized coatings for imparting wear-resistance to aluminum alloys.—*Allen Aircraft Products.*

Circle 130 on Inquiry Card for more data

Hard Carbides

Booklet on profitable utilization of high rigidity in a material that has three times the stiffness of hardened steel.—*Kennametal Inc.*

Circle 131 on Inquiry Card for more data

Field Coil Winding

Catalog gives technical details on 14 heavy duty transformer and field coil winding machines.—*Geo. Stevens Mfg. Co.*

Circle 132 on Inquiry Card for more data

Test Facilities

Bulletin (LCT - 611) describes technical services and equipment available.—*General Electric's Flight Propulsion Laboratory Dept.*

Circle 133 on Inquiry Card for more data

Sealed Valves

Brochure describes hermetically sealed valves for high temperature, high pressure service.—*Atomic Power Dept., United Shoe Machinery Corp.*

Circle 134 on Inquiry Card for more data

Thrust Measurement

Brochure describes electronic weight and thrust measurement systems used in ICBM's and Jet Aircraft. —*Gilmore Industries, Inc.*

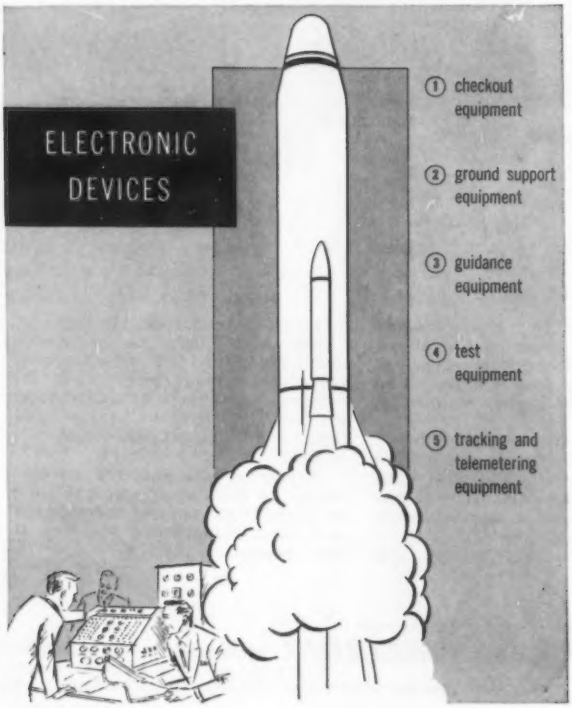
Circle 135 on Inquiry Card for more data

Information Electronics

Brochure on firm engaged in systems studies and development activities in the field of information electronics.—*Bissett-Berman Corp.*

Circle 136 on Inquiry Card for more data

Are you considering REINFORCED PLASTICS



THEN TAYLORON* MATERIALS BELONG IN YOUR PLANNING

WHAT TAYLORON MATERIALS ARE

Tayloron Reinforced Plastics are designed to meet the special requirements of missiles, space vehicles, and ground support equipment. They include metallic and nonmetallic materials laminated with plastic resins in many combinations and forms, vulcanized fibre in sheet, roll or fabricated parts, filament wound parts, materials and components engineered to perform specific functions, and pre-impregnated materials in filament, tape, wide sheet or roll.

ADVANTAGES OF TAYLORON MATERIALS

High strength-to-weight ratio. In terms of weight, they are considerably stronger than most metals. Moreover, their strength characteristics may be directed to meet stress demands. In filament or tape wound shapes, this property is even higher.

Comparative rigidity in cured condition. This prevents the part from bulging or otherwise deforming when high stresses are present. Thus original tolerances can be maintained under adverse operating conditions.

Excellent corrosion resistance. High resistance to both atmospheric and chemical corrosion. This is particularly important in structural members where corrosion could generate failure locations.

Dynamic Ideas

Pocket-size booklet "Dynamic Ideas in Materials" describes materials and products and their uses in missiles and aircraft.—*Rogers Corp.*

Circle 137 on Inquiry Card for more data

Hi Voltage Testing

Catalog describes instruments for testing of airborne electronic and electrical materials, components, and assemblies.—*Associated Research, Inc.*

Circle 138 on Inquiry Card for more data

Thor Delta Launch

Information on company's participation in the Thor Delta Launch Vehicle Program. — *The Electrosolids Corp.*

Circle 139 on Inquiry Card for more data

Materials

Pamphlet "Materials for Advanced Technology" describes new materials for applications requiring resistance to abrasion, chemicals, corrosion, nuclear radiation, and high temperatures.—*Research & Development Div., The Carborundum Co.*

Circle 140 on Inquiry Card for more data

Aviation Electronics

Catalog "Modern Aviation Electronics," describes airborne and ground communication and navigation equipment.—*Wilcox Electric Co., Inc.*

Circle 141 on Inquiry Card for more data

Aluminum Selector

Design file contains data on alloy sheet, coil and blank most often used by designers and engineers.—*Fairmont Aluminum Co.*

Circle 142 on Inquiry Card for more data

Corrosion Testing

Brochure describes line of metal finishing and corrosion testing equipment.—*Singleton Co.*

Circle 143 on Inquiry Card for more data

Micro-Modulator

Pamphlet on solid state magnetic modulator for low level instrumentation.—*James Electronics, Inc.*

Circle 144 on Inquiry Card for more data

Antennas

Facilities brochure includes firm's antenna pedestals, tracking and servo systems, sub-assembly components and other products.—*Temec, Inc.*

Circle 145 on Inquiry Card for more data

Machinable Carbide

Manual on machinable steel-bonded carbides.—*Chromalloy Corp., Sintercast Div.*

Circle 146 on Inquiry Card for more data

Rulon and Teflon Parts

Brochure describes qualities of RULON and Teflon. — *Plastics Div., Dixon Corp.*

Circle 147 on Inquiry Card for more data

Temp Control

Catalog on "Thermo Electronic" Multi-Point Controller. — *Thermo Electric Co., Inc.*

Circle 148 on Inquiry Card for more data

Systems

Brochure describes capabilities of firm for design, development and production of missiles, rocket and weapons systems.—*United Systems Corp.*

Circle 149 on Inquiry Card for more data

Switchboard Instruments

Bulletin (GEZ-3308) describes low cost switchboard instruments.—*General Electric Instrument Dept.*

Circle 150 on Inquiry Card for more data

Electronic Components

Booklet describes new concept in three-dimensional modular packaging and interconnecting of electronic components.—*AMP Inc.*

Circle 151 on Inquiry Card for more data

Weight Sensing

Reference manual on automatic weight sensing systems.—*The Exact Weight Scale Co.*

Circle 152 on Inquiry Card for more data

Torque Measuring

Brochure on measuring torque characteristics and speed of motors.—*Power Instruments, Inc.*

Circle 153 on Inquiry Card for more data

for high-performance components and assemblies?

Low heat transfer. This characteristic, under extremely high temperatures, makes Tayloron materials ideal for protecting structural members in missiles.

Good ablation qualities. This capacity to keep performing their basic function despite loss of some of their structure is a characteristic of some reinforced plastics. Tayloron materials offer the additional advantages of dissipating energy and thus reducing stress on other members.

Ease of fabrication. A wide variety of shapes may be made to close dimensions by molding, laminating or winding of filament or tape. Tayloron materials are readily fabricated and machined.

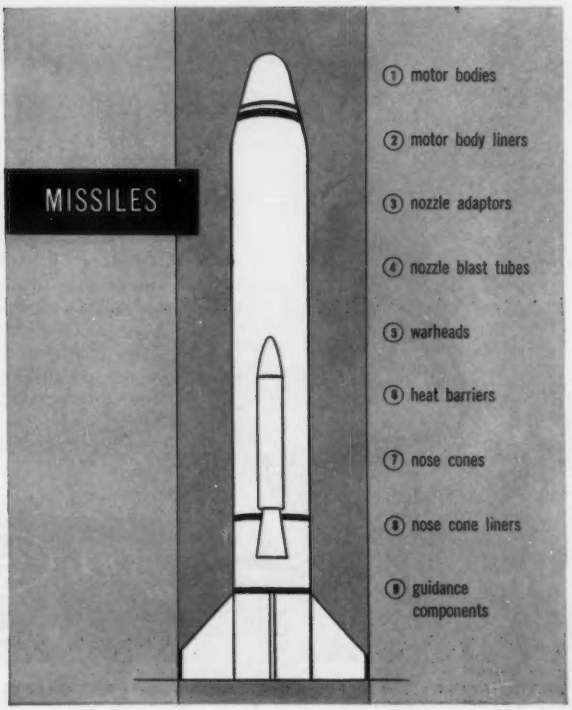
HOW TAYLOR CAN HELP YOU

In designing components and assemblies, consult our Advanced Materials Division on how to choose the best material and minimize the cost in reinforced plastics. Taylor can supply materials for any test or evaluation program—or completely fabricate assemblies. Special Tayloron materials have been developed for many specialized applications. Write the Advanced Materials Division outlining your specific problem. Taylor Fibre Co., Norristown 50, Pa.

*Trade name for Taylor Fibre's space, missile and astronautic materials

Taylor

REINFORCED PLASTICS ■ VULCANIZED FIBRE



Circle 20 on Inquiry Card

SILICONE NEWS from Dow Corning

By Jupiter... it's reliable!

Reliable . . . that one word sums up the record established by the Army's Jupiter and the performance of Silastic®, the Dow Corning silicone rubber is part of that record.

Rubber ducts must not crack even though frozen hard and brittle by liquid nitrogen. Access door seals must remain a rubbery seal despite high skin temperatures. Rubber parts must be "ready-to-go" even after long storage without signs of aging cracks. Chrysler Missile Division engineers specified Silastic to help keep the Jupiter ready . . . Silastic, flexible from —130 to 500 F and ageless in storage.

Photo courtesy Chrysler Missiles Division

Write to Dept. 0317 for information

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

Circle 21 on Inquiry Card

Where control depends on measurement!
CON-O-PAK THERMOCOUPLES
FROM -300°F TO 4000° PLUS
The world's finest thermocouples. New process increases precision and temperature range. Exceeds all military and commercial specs. Con-O-Pak is used in aircraft, missiles, nucleonics, chemical processing.
Useful data? . . . Ask for "The Con-O-Pak Story."
CON-O-PAK
CONTINENTAL SENSING INC.
N. Ruby St., Melrose Park, Illinois

FLEXIBLE AND SHEATHED THERMOCOUPLES • THERMOCOUPLE WIRE • HEATING ELEMENTS • CONNECTORS

Worth Asking For

Circuit Handbook

Handbook on circuit design of the tunnel diode.—*Transitron Electronic Corp.*

Circle 154 on Inquiry Card for more data

Systems Fabrication

Catalog shows facilities of manufacturer of finishing and processing equipment and systems.—*R. C. Mahon Co.*

Circle 155 on Inquiry Card for more data

Space Age Relay

Brochure on Mark II relay and its uses in advanced environmental applications.—*Electro-Tec Corp.*

Circle 156 on Inquiry Card for more data

HV Accelerator

Brochure on high voltage accelerator includes information on firm's facilities for research and development.—*Radiation Dynamics, Inc.*

Circle 157 on Inquiry Card for more data

Closed Circuit TV

Paper contains diagrams and specifications of system. — *Tung-Sol Electric, Inc.*

Circle 158 on Inquiry Card for more data

Systems Laboratories

Booklet describes activities of firm in space communications and radar. —*Sanders Associates, Inc.*

Circle 159 on Inquiry Card for more data

Bolt For 1200 Deg F

Folder on higher strength 1200 deg F aircraft bolt.—*Aircraft/Missile Div., Standard Pressed Steel Co.*

Circle 160 on Inquiry Card for more data

Data Handling

Brochure on activities of firm in data handling and missile component fields.—*Clary Corp.*

Circle 161 on Inquiry Card for more data

Oxygen Sensor

Brochure on polarographic oxygen sensor.—*Beckman Instruments Inc.*

Circle 162 on Inquiry Card for more data

F4H Electrical System

Bulletin (GER-1704) describes integrated a-c electrical system aboard all-weather Mach II aircraft, F4H.—*General Electric Co.*

Circle 163 on Inquiry Card for more data

Telemeter System

Bulletin (GEZ-3312) on telemetering of KWHR readings from remote locations to central load dispatch office.—*General Electric Co.*

Circle 164 on Inquiry Card for more data

Temp Controls

Condensed catalog describes 17 different types of temp controls.—*Fenwal Inc.*

Circle 165 on Inquiry Card for more data

Oceanographic Equipment

Data on underwater equipment includes automatic cameras and sonar. —Edgerton, *Germeshausen & Greier, Inc.*

Circle 166 on Inquiry Card for more data

Hi-Pressure Regulators

Facilities and products brochure. —*Vacco Valve Co.*

Circle 167 on Inquiry Card for more data

Airborne Hydraulic Pump

Technical specifications on airborne hydraulic pumps. — *Kellogg Div., American Brake Shoe Co.*

Circle 168 on Inquiry Card for more data

Traveling-Wave Tubes

Catalog features high power traveling-wave tubes. — *Microwave Tube Div., Hughes Aircraft Co.*

Circle 169 on Inquiry Card for more data

Pressure Vessels

Facilities and capabilities of pressure vessel manufacturer are outlined in brochure.—*Airite Products, Inc.*

Circle 170 on Inquiry Card for more data

Precision Wirewound Resistors

Data on all sizes plus fully encapsulated types.—*HanJohn Co.*

Circle 171 on Inquiry Card for more data

Electronic Reliability

Brochure presents case history of the Tacan-Arn-21. — *Hoffman Electronics Corp.*

Circle 172 on Inquiry Card for more data

R & D Capabilities

Brochure on R & D capabilities for studies on plastics, ceramics, elastomers, and metals.—*H. I. Thompson Fiber Glass Co.*

Circle 173 on Inquiry Card for more data

Bayonet Thermocouples

Details on miniature bayonet thermocouples.—*Thermo Electric Co.*

Circle 174 on Inquiry Card for more data

Airborne Transformers

Brochure on airborne power conversion equipment. — *Chatham Electronics.*

Circle 175 on Inquiry Card for more data

Electronic System Testers

Technical data electronic system testers.—*Bendix Support Equipment.*

Circle 176 on Inquiry Card for more data

Beryllium Oxide

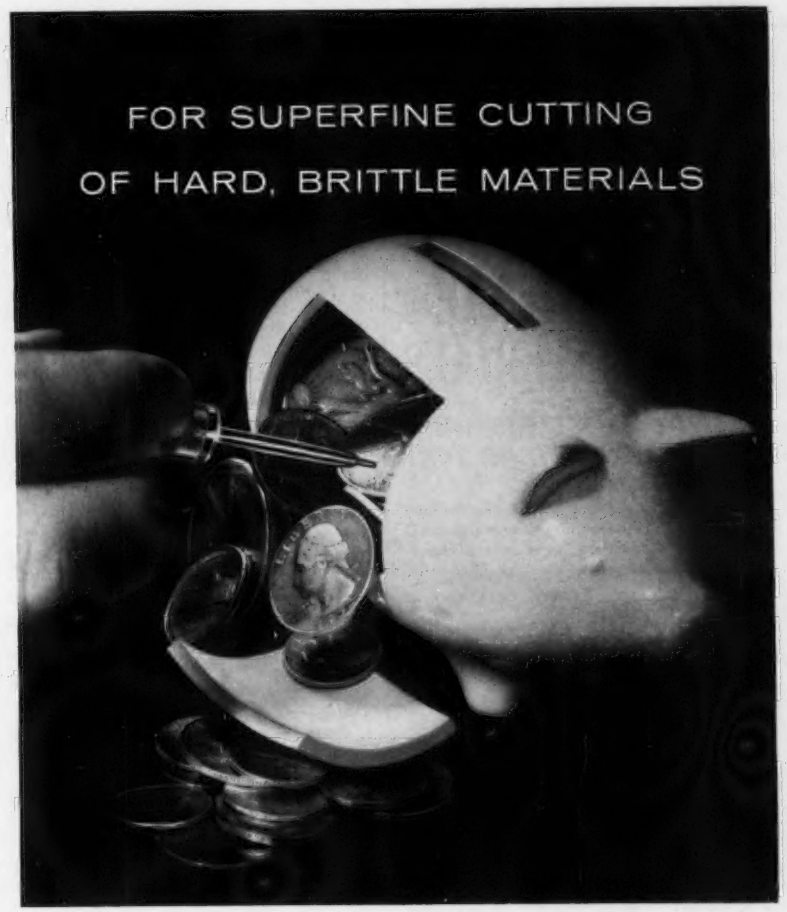
Paper entitled "Beryllia Aids Equipment Cooling."—*National Beryllia Corp.*

Circle 177 on Inquiry Card for more data

Redstone Management

Booklet describes operations of engineering documents section of the U. S. Army Rocket & Guided Missile Agency, Redstone Arsenal at Huntsville. — *Microfilms Products, Minnesota Mining and Mfg. Co.*

Circle 178 on Inquiry Card for more data



THE S. S. White Industrial Airbrasive® Unit

There may be easier ways to tap junior's piggy bank... but none that could craftily slice a piece out of a fragile ceramic part the way Industrial Airbrasive can.

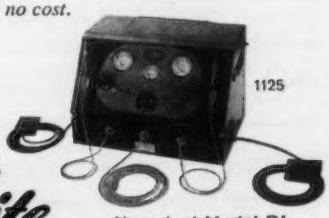
The secret of the Airbrasive's ability to cut hard, brittle materials is its accurate stream of gas-propelled abrasive. The cutting action is cool and completely shockless. Highly flexible in use, the same tool will make a cut as fine as 0.003" or it will frost, abrade or clean a large area.

Every day new uses are being found for the Airbrasive in production lines and in the laboratory... deburring small parts... shaping, drilling or cleaning germanium and other crystals... wirestripping potentiometers... removing fine films... printed circuits... micromodules... and many others!

Important too; the cost is low... for under $1,000 you can set up your own Airbrasive cutting unit!

Send us your most difficult samples and we will test them for you at no cost.

SEND FOR BULLETIN 6006 ... complete information.



S. S. White

New dual Model D!

S. S. White Industrial Division Dept. 18A 10 East 40th Street, New York 16, N. Y.

THE AUTHORIZED U. S. AIR FORCE EDITION OF

THE HANDBOOK OF THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS

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Signature_____

Company and address_____

Circle 24 on Inquiry Card

Worth Asking For

Electrical Termination

Engineering and manufacturing capabilities outlined in booklet. — *AMP, Inc.*

Circle 179 on Inquiry Card for more data

Pioneer Rocket Engine

Brochure presents case for Pioneer rocket engine as powerplant for manned space light programs.—*Reaction Motors Div., Thiokol Chemical Corp.*

Circle 180 on Inquiry Card for more data

Periscopes

Booklet on industrial periscopes for remote observation of inaccessible places or hazardous processes. — *Lenox Instrument Co.*

Circle 181 on Inquiry Card for more data

Stainless Steel Heads

Catalog of standard stainless steel heads.—*G. O. Carlson, Inc.*

Circle 182 on Inquiry Card for more data

Pressure Containers

Colorfully illustrated brochure of custom built compressed gas cylinders and pressure containers.—*The Marison Co.*

Circle 183 on Inquiry Card for more data

Temp Test

Brochure describes portable chamber for "proof-testing" of electronic components. — *Statham Instruments, Inc.*

Circle 184 on Inquiry Card for more data

Mini Module

Specifications on plug-in power supply module. — *Valor Instruments Inc.*

Circle 185 on Inquiry Card for more data

Quality-Reliability

Nov-Dec issue of Span with article on "Quality Assurance and Reliability."—*Hoffman Electronics Corp.*

Circle 186 on Inquiry Card for more data

Metallic Seals

Illustrated brochure on metallic seals.—*Harrison Mfg. Co.*

Circle 187 on Inquiry Card for more data

Pneumatic File

Leaflet on portable combination saw and file.—*Air-Speed Tool Co.*

Circle 188 on Inquiry Card for more data

Environmental Equipment

Brochure on environmental simulation chambers.—*Tenney Engineering Inc.*

Circle 189 on Inquiry Card for more data

***Super Clean Center for* KOHLER PRECISION CONTROLS**

Ultimate safeguard for reliable performance

Latest technological methods and surgical clean conditions for Kohler precision controls thoroughly eliminate contamination.

Hydraulic valves and other components are degreased and cleaned with ultrasonic facilities before assembly, testing, inspecting and packaging in the Super Clean Center. Air in the Center is filtered to 10 microns with temperature and humidity strictly controlled. Valves for missiles are heat sealed in individual air-tight containers.

With full facilities in one plant, Kohler Co. manufactures valves and fittings for aircraft, automotive, industrial and missile applications. Write for catalog.

KOHLER CO. *Established 1873*
KOHLER, WIS.

KOHLER OF KOHLER

Enameled Iron and Vitreous China Plumbing Fixtures • All-Brass Fittings • Electric Plants Air-Cooled Engines • Precision Controls

Circle 25 on Inquiry Card

New Materials

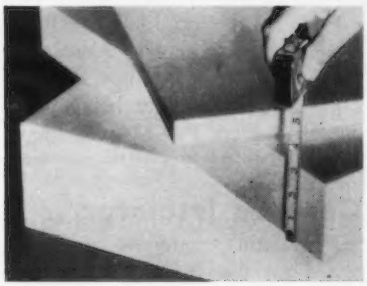
Nuclear Insulation

New all-metal insulation material will be used in a large nuclear power station at Oak Ridge. The material has been designed to resist radiation damage, and to withstand sudden pressure loss and severe thermal stresses.—Solar Aircraft Co.

Circle 190 on Inquiry Card for more data

Large Teflon Sheets

Sheet forms of Teflon TFE-fluorocarbon resin up to 8 inches thick and 25 inches square are now



available. The sheets are designed to provide fabricating savings and new design possibilities in the electrical, chemical and mechanical industries.—The Polymer Corp.

Circle 191 on Inquiry Card for more data

Silicone Rubber

New self-bonding silicone rubber compounds and reinforced gums afford a primerless bond to ferrous-containing metals.

Designated SE-5504U, the initially-available grade is a high strength, extreme low temperature compound similar to GE's standard SE-555. This material will be of use to mechanical rubber fabricators and to specialty manufacturers for shock mounts, rubber rolls, oil seals and a variety of other products for high-strength bonds. —Silicone Products Dept., General Electric Co.

Circle 192 on Inquiry Card for more data

Cleaning Solvents

Special blend of solvents can be used for cleaning electrical equipment such as motors while actually running the equipment, while immersed in the cleaning agents. These nontoxic and non-flammable fluorinated cleaning agents are du Pont Freon solvents, found to be particularly effective in removing oily soils from missile guidance systems. Will not harm complex materials of construction such as plastics, metals, electrical insulation, paints and varnishes.—Kyle Products Co.

Circle 193 on Inquiry Card for more data

Neoprene Adhesive

General purpose neoprene contact adhesive for bonding a wide variety of materials, giving bonds that have high peel strength, also displays good water resistance.—Industrial Div. Armstrong Cork Co.

Circle 194 on Inquiry Card for more data

Silicone Mold Spray

Immediate marking of parts with paint, ink, grease pencil or chalk is possible with Paintable Silicone Mold Release. Packed in a 16-oz aerosol can the new mold spray also allows easier painting of parts. Its "quick" release formula avoids "fish eyes" and poor adherence of the paint coating.—Industrial Supply Div., Sprayon Products Inc.

Circle 195 on Inquiry Card for more data

Lubricant

Permanent, solid dry-film lubricant called Surf-Kote, when bonded by a special process to the surfaces of metal components, provides a thin solid film which maintains its dry lubrication properties throughout the normal life of the components.—Stratos Div., Fairchild Engine and Airplane Corp.

Circle 196 on Inquiry Card for more data

Grid Board Kits

Fotoceram grid boards have been put into kits that provide a designer with all materials needed to make prototype printed circuitry in 15 minutes, without leaving his desk. The kits contain the etching resists and etching materials that work best with this copper-clad material.—Corning Glass Works.

Circle 197 on Inquiry Card for more data

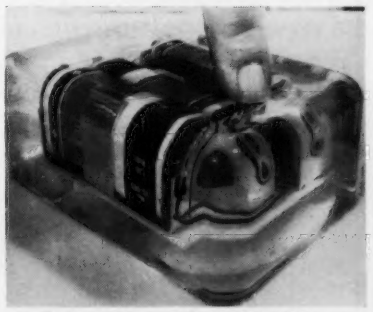
Urethane Foam

New urethane insulating foam, providing dimensional stability at sub-zero temperatures in a low-density formulation eliminates shrinkage.—Plastics Div., Nopco Chemical Co.

Circle 198 on Inquiry Card for more data

Potting Silicone

Clear solventless liquid silicone polymer when catalyzed, cures at low temp., below 100°C to form a resilient, transparent solid. As a

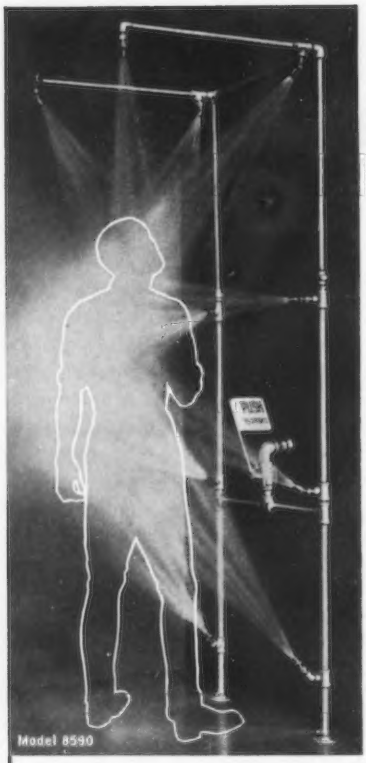


potting compound, LTV-602 provides transparency as well as protection against environmental hazards. Useful over a temperature range of –65 to 175 deg C, LTV-602 cures at temperatures that will not damage or affect most electronic components.—Silicone Products Dept., General Electric Co.

Circle 199 on Inquiry Card for more data

Chemical Energy Source

An entirely new and basic development in the production of chemical energy. Basic features of



contaminants off FAST!

HAWS SAFETY SHOWERS send torrents of rushing water from all angles – washing away dangerous irritants in a hurry!

Slap open the conspicuous "Push to Operate" valve. Hard-running streams from 10 *adjustable* nozzles drench victims in seconds.

You can depend on HAWS for the instant, *positive* first aid so vital until medical help arrives.

This "Safety on tap" can mean the difference between temporary irritation and permanent injury. Get the facts! Write for HAWS new safety catalog. Do it today!

Valve shown three-quarters open.

HAWS DRENCH SHOWERS

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Circle 26 on Inquiry Card

New Materials

the development are: the high velocity of the reaction; and low temp activation. The energy release can be accomplished in fractions of one second producing heat energy values of from 1500 deg C to 2000 deg C, or more, from a supplied level in the area of 100 deg C.

The direct conversion technique is entirely physio-chemical, producing energy as a primary product and chemicals, metals, or their combinations as a secondary product. For the production of energy the process has application for solid propellant fuels in missiles or rockets or for the manufacture of explosives.—Micronized Metals Inc.

Circle 200 on Inquiry Card for more data

Boron Pyralloy

Producer of pyrolytic graphite has introduced a new material, boron pyralloy, which could reduce the size and weight of components currently made of P. G. because of the 70 per cent greater strength of the boron pyralloy. Evaluation samples have demonstrated high bend strengths at temps above 1800 deg C.—High Temp. Materials, Inc.

Circle 201 on Inquiry Card for more data

Anti-Static Fluid

Chemical fluid prevents build-up of static charges on plastic-faced instruments. Static electricity on meter and instrument windows deflects pointers, causes faulty readings, and attracts and holds airborne dust and dirt. The new anti-static fluid provides a thin transparent coating which drains off static electricity.—Weston Instruments Div., Daystron, Inc.

Circle 202 on Inquiry Card for more data

Silver-Cadmium Cells

New method of attaining maximum recombination of generated gas allows the design of sealed silver-cadmium cells to meet the exacting power requirements of satellites, portable communications and other electronic systems that demand maintenance-free operation, high capacity and long life.—Yardney Electronic Corp.

Circle 203 on Inquiry Card for more data

Free Machining Stainless

Free machining chromium-nickel stainless steel, designated Uniloy 303MA. Compared with regular free machining AISI type 303, permits increased output of machined parts and longer tool life. Attributes of material include improved corrosion-resistance and surface finish. — Universal-Cyclops Steel Corp.

Circle 204 on Inquiry Card for more data

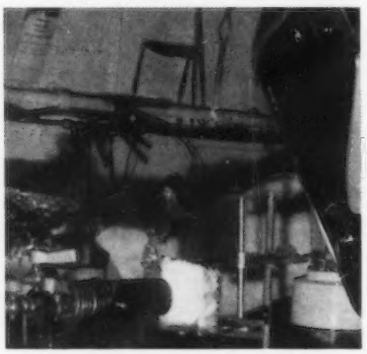
Ceramic Adhesive

New ceramic adhesive has superior bonding strength when used with refractory materials such as ceramics. Called melbond Ca-100, ready-to-use material was originally formulated for use with melfoam Ceramic Dielectric and possesses a maximum service temperature of 2600 degrees F. after being cured at 250 degrees F.—Melpar, Inc.

Circle 205 on Inquiry Card for more data

Ceramic Insulator

Insulating materials are being tested for use in uncooled engine skirts. Ceramic heat insulator is cured during cycle of about 30 hours. Temp is gradually increased to 900 deg F. After overnight cooling, panel which is coated with insulation is as hard as cement. Picture shows panel being tested in



front of torch. Coated panel is undamaged at 4000 deg F.—Rocketdyne Div., North American Aviation, Inc.

Circle 206 on Inquiry Card for more data

K. FALCK-PEDERSEN tells how Lindberg equipment helps produce gears for high-pressure pumps

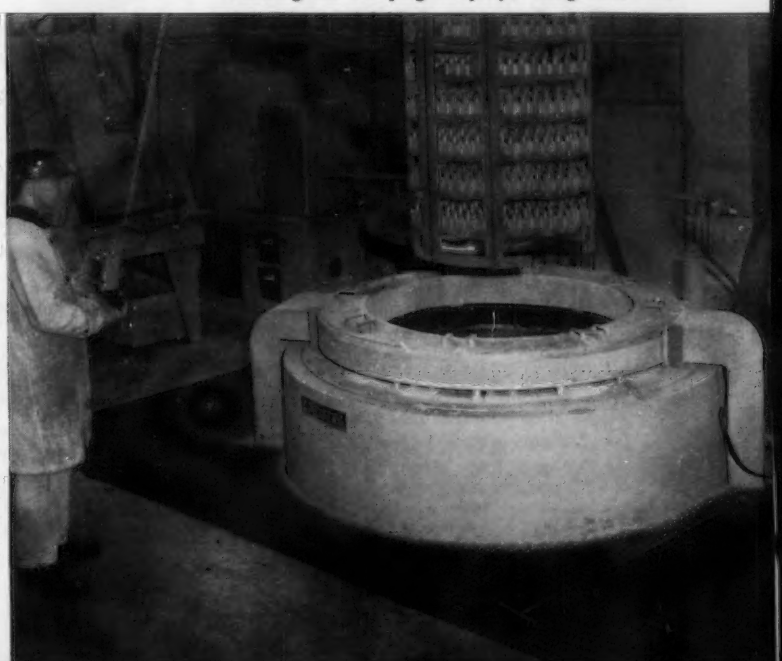
QUOTE

Mr. K. Falck-Pedersen, Chief Engineer, Commercial Shearing and Stamping Company, Youngstown, Ohio.

"The Lindberg heat-treating furnaces and atmosphere generating equipment installed in our Youngstown plant two and one-half years ago provided a fine solution to a big problem of ours. The units now give us complete and precise control over hardening and treating of gears for our high-pressure pumps. During these years, the equipment has proven trouble-free, required little maintenance and has proved to be remarkably easy to operate."

COMMERCIAL shearing & stamping

Gears being loaded in Lindberg Furnace at Commercial Shearing and Stamping Company, Youngstown, Ohio.



Lindberg equipment at Commercial is used for carburizing gears for high-pressure pumps and allows mass production of practically distortion-free gears, while holding the degree of hardness as well as depth of case to very close tolerances—load after load after load. The installation includes one electric and two gas-fired furnaces, Lindberg Hyen Atmosphere Generator and Carbotrol.

If you have a problem in heat treating, why not get the Lindberg representative's help now? You can depend on his experience and Lindberg's engineering and design know-how to provide exactly the right equipment for your need. And it's easy, too! Just call your Lindberg Field Engineer (he's listed in your classified phone book) or write us direct. Lindberg Engineering Company, 2473 West Hubbard Street, Chicago 12, Illinois.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, Spain, Switzerland and West Germany.

LINDBERG heat for industry

Circle 27 on Inquiry Card

New Electronic Products

Miniature Accelerometer

Low cross axis response, minimum damping change with temperature, and high resonant frequency are features of this strain gage ac-

celerometer. Unit was designed to measure accelerations parallel to mounting surfaces. — Consolidated Electrodynamics Corp. Sub. of Bell & Howell.

Circle 207 on Inquiry Card for more data

Airborne Pressure Transducer

New medium-to-high range pressure transducer utilizes the unbonded strain gage principle with a four-active-arm spring type sensing element and diaphragm force summing area. Designed as a chamber type unit, the 4-329 is capable of performing absolute measurements of fluid compatible with type 416 stainless steel in pressure ranges from 0-100 psi through 0-5000 psi. —Transducer Div., Consolidated Electrodynamics Corp.

Circle 215 on Inquiry Card for more data

Static Inverter

Static inverter is designed to power a synchronous motor for use in magnetic tape recorders. With the manually adjustable frequency control, tape speed can be adjusted ± 10 per cent. With external synchronization tape speed can be locked into an external frequency reference or slaved to other tape drives. The Static Inverter is designed to convert 22 to 28 VDC into three phase 220 VAC, 60 cycles power to drive a Westrex Type RA1334-A or equivalent synchronous motor. — Kidde Electronic Laboratories.

Circle 209 on Inquiry Card for more data

Event/Environmental Recorder

Automatic freight monitor keeps a watchful eye on shipments of costly precision products and delivers a second-by-second report on en-route events and environment. The modular device records such physical phenomena as impact or acceleration, temperature, differential or total pressure, electrical resistance, etc. A rechargeable battery power supply permits a full month of continuous unattended operation. — Lockheed Aircraft Service.

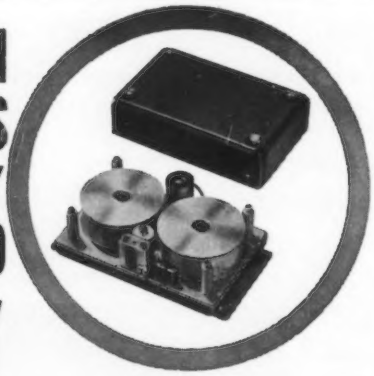
Circle 212 on Inquiry Card for more data

Airborne PCM System

New PCM system for telemetering digital data during flight tests of high-performance aircraft and missiles, employs all silicon solid-state circuitry, welded construction, high-density packaging, and vacuum-encapsulated modules. Unit is capable of withstanding wide temperature range, high random vibration, and large shocks and accelerations without effect. A complete 48 channel system occupies only 250 cubic inches and weighs less than 14 lbs. A complete system normally consists of three interconnected packages.—Electro-Mechanical Research, Inc.

Circle 210 on Inquiry Card for more data

BEATTIE-COLEMAN PROGRAMER OFFERS 99.999% RELIABILITY



4 HOUR PROGRAM ON 13 CHANNELS

Reliability of the Beattie-Coleman MLPR-13 Programer has been thoroughly **proved** in numerous successful missile applications and in rigorous laboratory tests. This precision instrument offers these important features:

- 13 channels.
- Not affected by magnetic fields.
- Controls programs up to 4 hrs. 42 mins. duration.
- Accommodates 160 ft. of punched 35mm Cronar tape.
- Available in 8 tape speeds.
- Tapes quickly changed for varying programs.
- Compact, light weight.
- Timing accuracy: Repeatability ±0.05%.
- Temperature: 0° to 65°C.

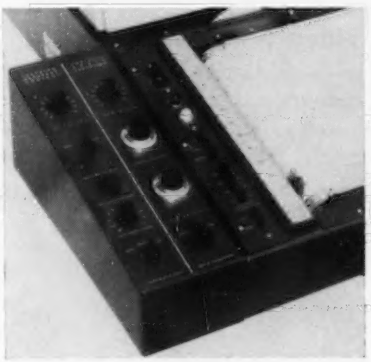
Other models to fit your needs. Write for catalogs.

Coleman BEATTIE-COLEMAN INC.

1050 West Olive, Anaheim, Calif. Branch 437 Fifth Ave., New York, N. Y.

Tracking Accuracy Control

TAC unit, which minimizes spectra inaccuracies in frequency and band intensity is designed for use with the IR-4 and IR-7 Infrared Spectrophotometers.



This new accessory performs three functions: automatic slit control, automatic speed suppression, and automatic period suppression. —Scientific & Process Instruments Div., Beckman Instruments Inc.

Circle 216 on Inquiry Card for more data

Rectifier Power Supply

Compact wide range, voltage regulated, 30 ampere d-c power supply, incorporates new silicon controlled rectifiers. Unit will deliver 50 amp for one minute or 30 amp continuous duty, with a voltage adjustment range of 2 to 36 volt.—Christie Electric Corp.

Circle 217 on Inquiry Card for more data

Tape Recorder Analyzer

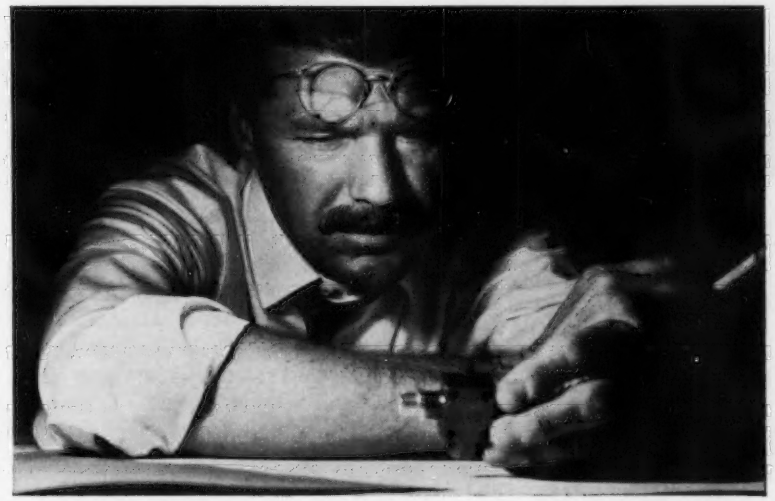
Single unit contains solid state analyzer for rapid and complete checkout of any digital tape recorder. Unit is capable of performing all fundamental measurements to determine operations status of a recorder. Where operational errors occur, the analyzer either eliminates the tape recorder as the source or locates the trouble area. — Telemetrics, Inc.

Circle 218 on Inquiry Card for more data

10-Turn A-C Potentiometer

New potentiometer has high input and output impedance, thereby reducing quadrature and loading effects. New design minimizes the

continued on next page



MAJOR PROBLEM...in Propellant-Actuated Devices?

If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to Horkey-Moore Associates about propellant actuated devices. HMA has a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. HMA's extensive facilities for engineering, manufacturing and testing are available. Call or write today.

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Circle 28 on Inquiry Card

What more do you want GRAPHITE to do for you ?

Graphite has been useful in aircraft and missile problem-solving as a component material in rocket motors, in brazing fixtures for airframe construction, and in other refractory applications.

Further and more advanced uses of graphite in space age progress may well be developing now as part of your design engineering program. We would welcome the opportunity of having our engineers, technicians and production personnel assist you in these developments.

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Circle 29 on Inquiry Card

New Electronic Products

chance of failure, and provides exceptional linearity that's stable over the entire life of the unit.—Helipot Div., Beckman Instruments, Inc.

Circle 219 on Inquiry Card for more data

Miniature Accelerometer

Newly developed telemetering unit is available in resistance ranges from 2000 to 5000 ohms yielding a 0.5 per cent resolution.—Giannini Controls Corp.

Circle 220 on Inquiry Card for more data

Transistor Tester

Rapid testing of NPN and PNP transistors is said to be possible with transistor tester model T-340. Instrument measures the four basic parameters necessary to check a transistor's performance.—Magnetic Research Corp.

Circle 221 on Inquiry Card for more data

Frequency Standard for Missiles

Designed primarily for missile or other airborne applications, a new 400 cps crystal frequency standard features extremely high stability under rugged environmental conditions and varying input voltages.—Electronics Div., Bulova Watch Co., Inc.

Circle 222 on Inquiry Card for more data

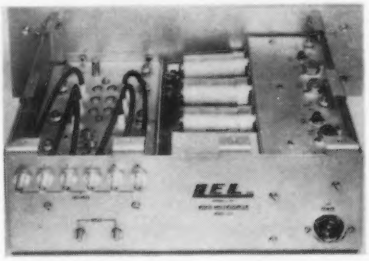
Signal Conditioning Amplifier

DC Signal Conditioning Amplifier is designed to amplify the output from strain gauges, thermocouples, or similar transducers for telemetry purposes. Completely transistorized, the amplifier incorporates a converter to isolate signal circuits from power circuit and is designed to withstand ballistic missile environment.—Electro Development Corp.

Circle 223 on Inquiry Card for more data

Video Multicoupler

Multicoupler uses all solid-state circuitry and provides, in a self-contained rack and panel assembly, six emitter follower outputs driven from



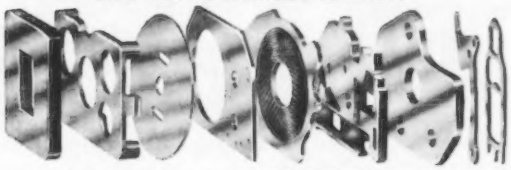
a single input. A band-width of 40mc and a gain of 12db is provided. Isolation between channels is greater than 50db at 10mc.—LEL Inc.

Circle 224 on Inquiry Card for more data

DOUBLE DISC GRINDING SERVICE

Don't waste your time & don't spend a fortune to get, at best, inferior results by using obsolete methods such as: Fly cutting, face turning & surface or face grinding.

LET US QUOTE on all your parts requiring TWO FLAT & PARALLEL SURFACES



Your tolerances, materials and shapes won't scare us, but they may affect our prices! Talking about prices, we're sure that by our doing the job the right way we won't have any competition from anyone doing it the hard way.

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Round Discs & Rings from ⅛" dia. to 30" dia.
Rectangular Plates up to 14" x 24".
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Circle 30 on Inquiry Card

NEW, lighter weight flexible BALL joints for CRYOGENIC piping

SIZES: 3", 4", 6", 8", 10", 12"

FOR PROJECT REQUIREMENTS—In handling fluid fuels and oxidizers, including liquid oxygen. Also in industrial cryogenics for liquid methane and liquid propane or butane at low, as well as ambient, temperatures.

RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.

NEW, ADVANCED DESIGN—Has passed official "Qualification Tests," including shock tests of more than 100G's. TEMPERATURES: −320°F to +275°F. PRESSURE RATING: Designed for and qualification tested at 200 psi operating, 300 psi proof, 700 psi burst pressures. *Ask for Bulletin 233 B.* BARCO MANUFACTURING CO., 565 F Hough St., Barrington, Illinois.

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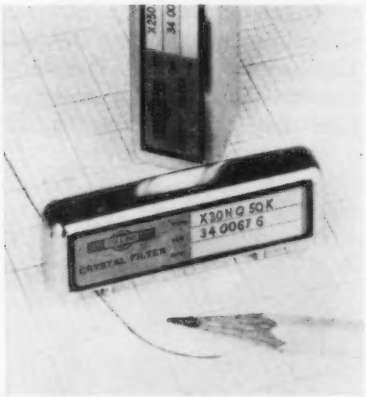
Circle 31 on Inquiry Card

New Parts and Components

Crystal Filters

New line of crystal filters for a broad range of applications in single sideband, telemetering, missile guidance, radar and navigation equipment and other communication and electronics uses. Crystal filters over the 10 kc to 30 mc



frequency range are now being produced in quantities. One of the new units is a 5 mc filter in a thumb-size case.—Western Div., Collins Radio Co.

Circle 225 on Inquiry Card for more data

Dual Counter

Solid state 100 KC dual predeterminer counter features high speed operation, concentric dual control, bright in-plane display and compact portable carrying case. For use in programming, measuring, and automation operations. Operates from any standard 115.-v ac 60-cycle power source. — Robotomics Enterprises, Inc.

Circle 226 on Inquiry Card for more data

Transfer Container

New portable constant temperature container equipped with elaborate warning safeguards serves both as a carrying case or storage cabinet for vital submarine and missile guidance components. The cabinet maintains temperatures within 2.5 deg of the original setting within a

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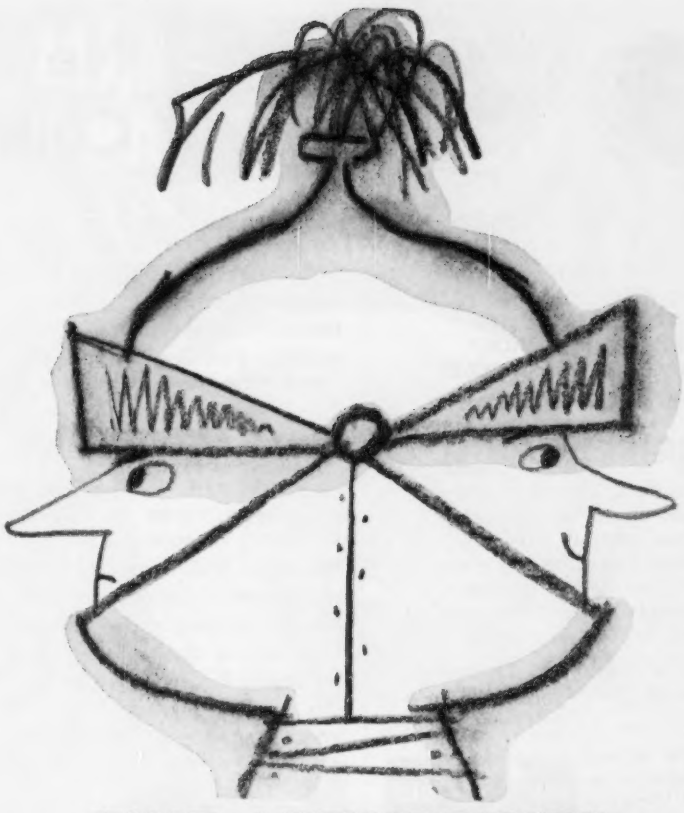

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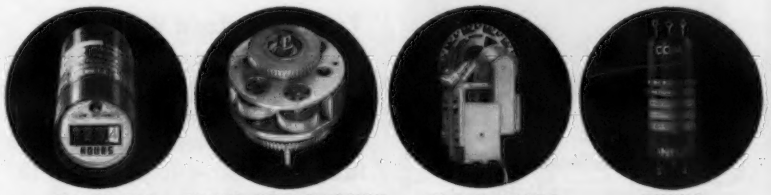
. . . would have been a big asset for an afternoon of mayhem at Camelot. But they're even more important when it comes to solving design or production problems, especially when you are looking for a fresh approach. If your problem involves precision sub-miniature component assemblies—mechanical, electro-mechanical or electronic—let Elgin Micronics supply the fresh approach. We're organized to integrate our capabilities (and viewpoint) with yours at any stage of design, engineering or manufacture. May we visit your plant?



RECORDING POWER TRANSMISSION PROGRAMMING TIMING

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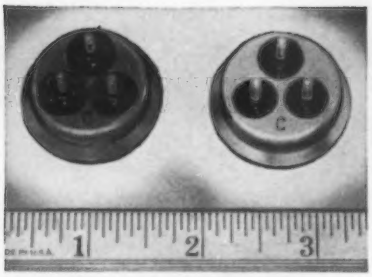

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Vapor Blast Liquid Honing process cleans metals fused to glass without removing glaze or damaging the glass.

Yet the metal parts are thoroughly cleaned, burrs removed, in shortest possible time.

Bring or send parts for test cleaning. No obligation.

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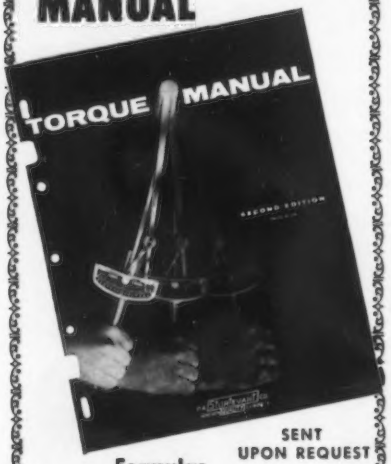
Circle 33 on Inquiry Card

"TORQUE WRENCH" MANUAL



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Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Circle 34 on Inquiry Card

New Parts and Components

(*continued from page* 73)

temperature range of 110 deg F to 175 deg F. Warning "alarm" lights indicate temperature deviation. A remote warning system may be connected.—Precision Scientific Co.

Circle 227 on Inquiry Card for more data

Self-Sealing Fasteners

A new line of self-sealing captive screws require no tapping of the panel, or special tools for installation, and they can be used in standard clearance holes. These fasteners employ a grip ring on the blind side of the panel as a retaining device. Easily slipped into place, this grip ring prevents accidental unscrewing.—A. P. M. Corp.

Circle 228 on Inquiry Card for more data

Radar Altimeter

New all-weather radar altimeter that can provide a range of zero to 5,000 ft was designed to measure distance from an aircraft to the nearest surface. It measures the elapsed transit time of a radar pulse and converts the signal directly to altitude on an indicator.

The receiver - transmitter unit and the antenna coupler are in separate boxes. The lightweight system can be installed almost anywhere within an aircraft. — The Bendix Corp.

Circle 229 on Inquiry Card for more data

Transistorized Voltmeter

Model V-70 covers a full DC range from 1 millivolt to 999.9 volts, and includes a built-in safety circuit to protect the instrument from input over-voltages. Reads DC voltages with an accuracy of 0.01 per cent, plus or minus one digit. Operator may read voltages between 0.000 and 1000 volts DC with an average balance time of 500 milliseconds and a maximum read-out time of 750 milliseconds. The V-70 weighs 28 lbs, is 19″ wide, 5¼″ high, 14″ deep, can be rack or bench mounted and has a dust-proof switch and bridge section.—Cubic Corp.

Circle 230 on Inquiry Card for more data

DC Motor

DC motor designated PM-1 was originally developed for NASA's Tiros weather satellites. The vibration and shock resistant motor requires very low input current at full

load, and provides power outputs equal to motors 50 per cent larger. Weighing less than 2½ ounces, the motor is only ⅞ths inch in diameter and less than 2 in. long.—Reflectone Electronics, Inc.

Circle 231 on Inquiry Card for more data

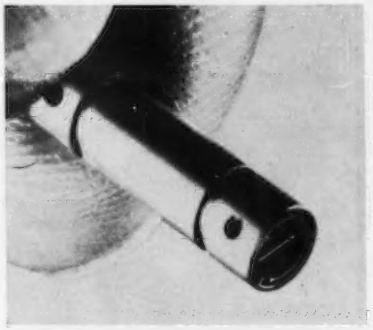
Control Valve

Self-draining control valve for high energy exotic rocket fuel lines, both at launching and test facilities. Body designed so that all surfaces slope down-stream, making the valve completely self-draining.—The Annin Co. Div. of The Worthington Corp.

Circle 232 on Inquiry Card for more data

Non-Friction Bearing

Called the Flexural Pivot, this bearing is a simplification of the



more complex cross-spring pivot. Key to the bearings operation is that flat steel springs form a sort of web between two separated "halves" of a tubular bearing. The flexing of these springs allows movement up to a 60 deg. arc—with no rubbing of one part against the other. Use: Altitude control devices, gyros, and rocket steering units.—The Bendix Corp.

Circle 233 on Inquiry Card for more data

Strain Gage

Bonded resistance-foil strain gage has a built-in computer that solves general strain-to-stress equations automatically. Gage will simplify the task of obtaining stress readings in a wide range of testing and measuring applications — by automatically eliminating the need for time consuming calculations of stresses from the strain indications.

Gages are available with a phenolic base construction and Constantan foil, with resistance ratios and temperature compensation for mild steels, stainless and aluminum. —Electronics and Instrument Div., Baldwin-Lima-Hamilton Corp.

Circle 234 on Inquiry Card for more data

Speed-Sensitive Switch

Designated S-10 this switch is designed for high accuracy over a wide range of environmental conditions. Rated performance for the unit is a switching error not to exceed ±1.5 per cent of the rated speed over all environmental conditions. Unit weighs 1.0 lb.—The Cosmodyne Corp.

Circle 235 on Inquiry Card for more data

continued on next page

MARKS UP TO 7,000 PARTS PER HOUR

. . . Cylindrical or Cone-Shaped
. . . Solid or Tubular Design

MATTHEWS ROTARY TABLE MARKING MACHINE

The Matthews Rotary Table Marking Machine positions, marks, and ejects parts automatically at speeds up to 7,000 per hour. Your name, trade-mark, part number or special lettering appear perfectly even on hard-to-mark, delicate and thin-walled products.

Solid marking dies may be interchanged with steel type or logo dies for variable marking . . . interchangeable machine heads are available for parts of varying size and design. Mark it with a Matthews Rotary Table Marking Machine . . . faster, clearly and more economically. Write for descriptive Bulletin 146-C9.

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Circle 35 on Inquiry Card

ROPES FOR SPACE TECHNOLOGY?

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Puritan manufacturers the largest variety of ropes in the world including ropes of special synthetic and natural fiber. Your inquiry will receive prompt attention. **You can depend on Puritan; others have!**

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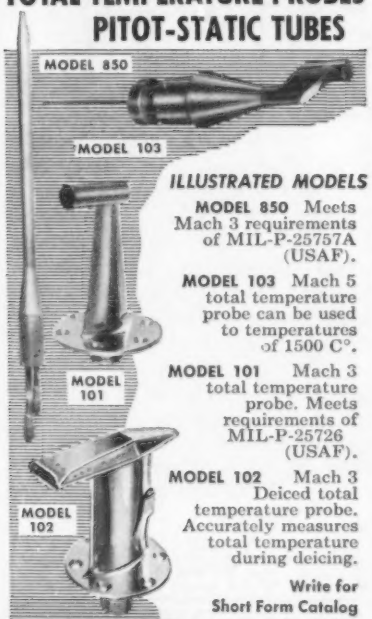
Circle 36 on Inquiry Card

TOTAL TEMPERATURE PROBES PITOT-STATIC TUBES



ILLUSTRATED MODELS

MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

MODEL 103 Mach 5 total temperature probe can be used to temperatures of 1500 C°.

MODEL 101 Mach 3 total temperature probe. Meets requirements of MIL-P-25726 (USAF).

MODEL 102 Mach 3 Deiced total temperature probe. Accurately measures total temperature during deicing.

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Circle 37 on Inquiry Card

New Parts and Components

Research Rockets

Rocket engines designed for operation with all known propellant combinations. Three nominal thrusts are available: 200 lb, 1000 lb, and 5000 lb. Firm also produces portable test stands, propellant evaluation systems and rocket training devices.—Astrosystems, Inc.

Circle 236 on Inquiry Card for more data

RF Filters

RF filters equipped with special fittings to accept any of the common subminiature connectors are now available. Units, both band pass and low pass types, are designed for

use in missiles, ground support systems and telemetering equipment. Design enables the receptacle to be oriented in any direction from the filter.—Telonic Engineering Co.

Circle 237 on Inquiry Card for more data

Phenolic Tubing

Developed to withstand radially applied compressive and burst forces this paper base tubing is available in diameters of ⅛ to 48 inches. Called HY488 the tubing will be useful in applications where high "hoop strength" is important, notably fuse tubes and rocket flare tubes. Axial flexural strength is

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- Tartar
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SEATON-WILSON is a pioneer in the design and fabrication of custom made quick disconnect couplings for the missile industry.

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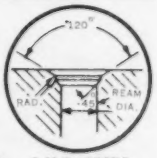
Circle 38 on Inquiry Card

Do you machine hydraulic parts?



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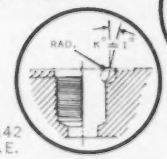
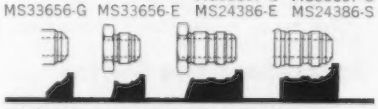
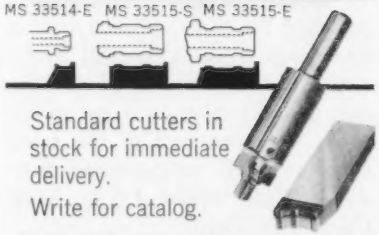


MS 16142 or S.A.E.

MS33656-G MS33656-E MS33657-E MS24386-E MS33657-S MS24386-S



MS 33514-E MS 33515-S MS 33515-E



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Circle 39 on Inquiry Card

NEW, PROVED

CONTAMINATION MEASUREMENT

electronically count contaminants in:

- *hydraulic oils*
- *jet fuels*
- *white room air*

the

COULTER COUNTER®

Speed, accuracy, versatility previously unmatched. The non-optic Coulter Counter automatically performs selected size level counts of particles 1 by 1 from .3 micron to 200 microns and provides multiple levels of size detection simultaneously.

Typical counts

2 to 5 microns	13,332
5 to 10 microns	7,041
10 to 20 microns	3,101
20 to 40 microns	798
40 to 80 microns	181
Over 80 microns	52

Per 100 ml 5606 Oil.

NOTE: also used for accurate particle size distribution data on fine particles in solid fuels, ceramics, ammonium perclorate and other materials.

Write today for complete information and how the Coulter Counter can be applied to your requirements

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Los Angeles • New York

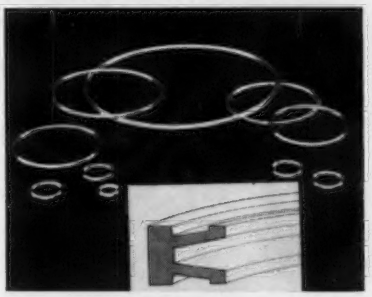
Circle 41 on Inquiry Card

19,650 psi, tensile strength is 12,-025, and ultimate fiber tensile strength is 33,750 psi. Comes in lengths up to 80 in. and wall thicknesses from 1/32 to 1 in.—Micarta Div., Westinghouse Electric Corp.

Circle 238 on Inquiry Card for more data

Static Face Seals

Metallic static face seals meet high pressure and extreme temperature requirements of systems in missiles and high performance aircraft.



HS Series Seal provides zero leakage at temperatures from —450 deg to +2000 deg F and pressures to 20,000 psi. HS Series Seals are manufactured in a wide range of materials: Inconel X, age hardened; A-286, age hardened; 17-4PH to H1150 hardening; 7056-T6 Aluminum; 18-8 CRES, heat treated; Tantalum, annealed, and most of these may be obtained with platings of silver, gold, indium, Teflon, Kel-F, copper, etc.—Haskel Seals Div., Haskel Eng. & Supply Co.

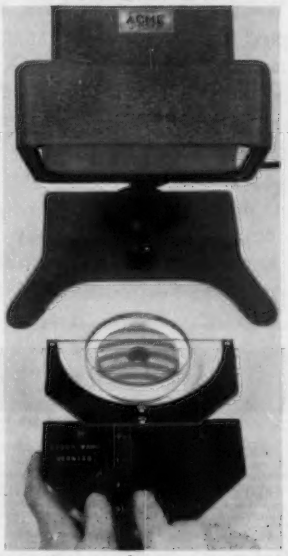
Circle 239 on Inquiry Card for more data

Hypersonic Wind Tunnel

Developed to test space vehicle behavior this tunnel is capable of producing momentary blasts of air up to 20 times the speed of sound. Tunnel is now being used to determine heating rates and hotspots on the skin of the Apollo. To create the blast a gas is heated in a cylinder that resembles a gun breech, the gas then has a temperature of 15,000 deg F and a pressure of 20,000 psi. Gas then forces an opening in layers of tough plastic that separates it from a vacuum on the other side. Gas spurts through the vacuum at 10,000 to 20,000 ft per second—The Martin Co.

Circle 240 on Inquiry Card for more data

.0000116" accuracy... actually measured



The simplest, quickest, most economical system for light wave measurement. Acme Scientific's monochromatic lamps, optical flats and now the Light Band Vernier.

- no special training necessary
- large bright work area eliminates "fussing around" with precise work placement
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new... Light Band Vernier The only measuring device created to be used with monochromatic lamps and optical flats

The Lamps Standard or direct viewing models available to cover optical flats up to 20" diameter.

The Flats Optically polished from selected blanks of Pyrex or quartz. Single or double surface accuracies to .000001". Consistent accuracy over entire surface.

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—— *lamps and optical flats*

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Firm

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Circle 40 on Inquiry Card

New for Production

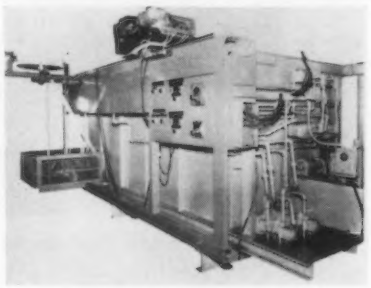
Positioning Equipment

Welding positioners have been adapted for use in testing radar antennas and for positioning X-ray heads for nuclear research. Positioner manipulates heavy antennas so that they can be tilted to any desired angle, and rotated through a complete circle. The X-ray heads can be moved 6 ft vertically and 6 ft horizontally, as well as rotated 90 deg from horizontal to vertical and 90 deg from side to side, all by remote control.—The Ransome Co.

Circle 241 on Inquiry Card for more data

Ultrasonic Scanner

Automatized ultrasonic scanning system is developed for missile and aircraft parts flaw detection. Scanner utilizes a tank five ft wide and



deep, and ten ft long. Uses an unlimited variety of speed setting controls.—Circo Equipment Co.

Circle 242 on Inquiry Card for more data

Automatic Time/Motion

A new total systems concept employing the Stanrecorder to provide for the fast, accurate recording of employee activities and the automatic entry of such data into machine accounting systems has been developed. The electromechanical unit eliminates the need for any manual transcribing of such information by recording the data in both machine and human language at the source.—The Standard Register Co.

Circle 243 on Inquiry Card for more data

Hydrogen Furnace

Elevator type hydrogen lock brazing furnace does not require a retort, yet maintains hydrogen atmosphere at dew points below —60 deg F using minimum flow rates. Small, self contained furnace is ideally suited for brazing, sintering annealing, stainless heat treating and metallic coating of ceramics. The elevator sections are power operated.—Pacific Scientific Co.

Circle 244 on Inquiry Card for more data

Automatic Tester

Versatile automatic specification tester (Vast I) is capable of 20—parameter "go-no-go" testing of 3600 transistors per hour. The equipment accommodates three operators, though more than two will seldom be required. Transistors are inserted in single unit sockets affixed to a conveyor system and are transported sequentially from station to station.—Lansdale Div., Philco Corp.

Circle 245 on Inquiry Card for more data

Ultrasonic Welder

New 4000-watt capacity ultrasonic spot-type welding machine incorporates 36-in. throat depth; has power source that can be remotely located from the welder, even on a different floor if desirable.

The ultrasonic coupling system has been redesigned to permit greater accessibility of the welding tips into hard-to-reach locations.—Sonobond Corp.

Circle 246 on Inquiry Card for more data

Scanning Device

A new general purpose scanning device for high-production surface hardening of various metals in rod or shaft form is now being offered as a standard accessory for use with H. F. induction generator units. Device features automatic speed controls, a spring-loaded centering

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system for easy mounting of work pieces, plus air-hydraulic drive for rapid cycling and high production rates.—C. I. Hayes, Inc.

Circle 247 on Inquiry Card for more data

Parts Feeder

Automatically feeds, orients, and dispenses a great variety of small

parts. Feeder consist of powered vibratory bases and universal feeder bowls. Each bowl is designed for fully interchangeable mounting of various orientation segments. The segment tooled to orient a particular part can be replaced quickly by another segment tooled for a different task.—USI Robodyne, Div. of U. S. Industries Inc.

Circle 248 on Inquiry Card for more data

Small-Parts Cart

A combination dump cart and hopper simplifies the handling of small parts during heat treating operations. Cart consists of a dolly with a tilting roller platform and a hopper. In operation, the basket load of parts is rolled onto the platform where the basket is clamped into position. A drain pan under the rollers collects excess oil accumlated during quenching operations. The hopper chute is then opened, and the platform is rotated to pour the parts into the hopper. An opening at the narrow end of the hopper chute permits controlled feeding of the parts into tote boxes or other containers.—Ipsen Industries Inc.

Circle 249 on Inquiry Card for more data

SPECIFY ZEUS CUSTOM-ENGINEERED ELECTRIC MOTORS

Pesco Engineering Production

PESCO B-W PRODUCTS BORG-WARNER

TO MEET YOUR SPECIFIC OPERATING AND PACKAGE REQUIREMENTS

✓ MINIMUM ENVELOPE SIZE

Extremely tight windings, low air-gaps, compact brush riggings, recessed armature end turns . . . keep Pesco motor sizes to a minimum.

✓ DYNAMICALLY BALANCED COMPONENTS

All rotating components . . . fans, rotors, shafts . . . are dynamically balanced—individually, and as complete assemblies.

✓ EXCLUSIVE COOLING ACTION

Pesco axial flow fan rotors provide exceptional aerodynamic cooling . . . assure extended motor life and efficient operation at elevated temperatures.

✓ COORDINATED FRAME DESIGN

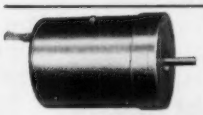
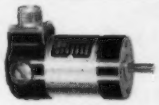
Standard coordinated frame sizes . . . custom-adapted to specific power requirements . . . give high horsepower-to-weight ratios. Basic motor diameters range upward from 1.25 inches.

✓ LIGHTWEIGHT PACKAGE

Cast aluminum end bells and bases, hollow shafts on specified models, high operating speeds . . . these features contribute to more horsepower per pound in Pesco motors.

✓ MIL SPEC DESIGN

Pesco electric motors . . . AC, DC, or miniaturized series . . . are built to the exacting standards of Mil-M-7969 and Mil-M-8609. When ordered, any Pesco motor will be qualified to these specifications.

	Horsepower Range	Motor OD	Weight
 AC MOTORS	.018 to 20	2.2 to 8.25″	.8 to 90 lbs.
 DC MOTORS	.005 to 5 (cont) .3 to 15 (int)	1.75 to 4.75″	1.3 to 21.5 lbs.
MINIATURIZED AC AND DC MOTORS	.003 to .09	1.25 to 1.68″	4.8 to 12 oz.

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
Dept. M-5, 24700 N. Miles Rd.
Bedford, Ohio

Please send me complete information about Pesco Electric Motors.

Name_____
Company_____
Street_____
City_____ Zone____ State_____

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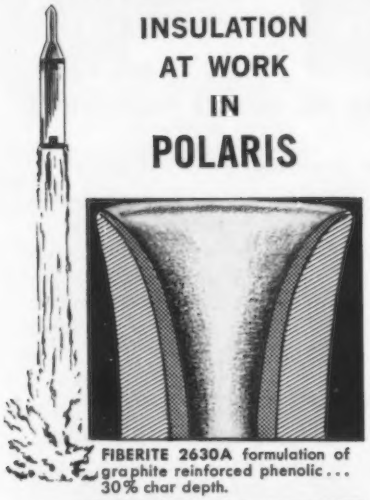
example...

FIBERITE

INSULATION AT WORK IN POLARIS



FIBERITE 2630A formulation of graphite reinforced phenolic... 30% char depth.

Char Depth

Standard graphite reinforced phenolic 100% char depth.

The development of special Fiberite MX 2630A formulations reduce char depth of graphite reinforced phenolic molded insulations up to 70%, thus permitting the use of these materials in more critical solid propellant rocket motors.

Cut-away sections above illustrate reduction of char depth by utilizing Fiberite molding material.

EXPLORE FIBERITE

Missile engineers will find our research helpful in solving problems requiring materials for special performance. Write factory for bulletin "Fiberite High Temperature Insulating Materials."

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514 W. 4th Street
Winona, Minnesota
MOLDING COMPOUNDS

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- ....3. Production
- ....4. Procurement

B. Type of Plant or Facility

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- ....2. Propulsion
- ....3. Electronic Systems & Parts
- ....4. Mechanical Systems & Parts
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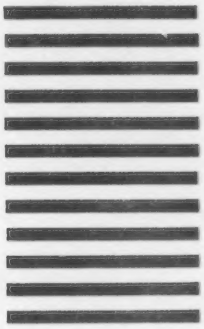

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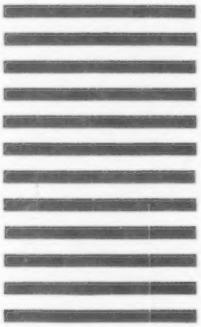

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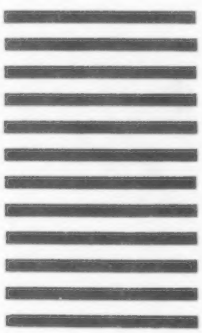
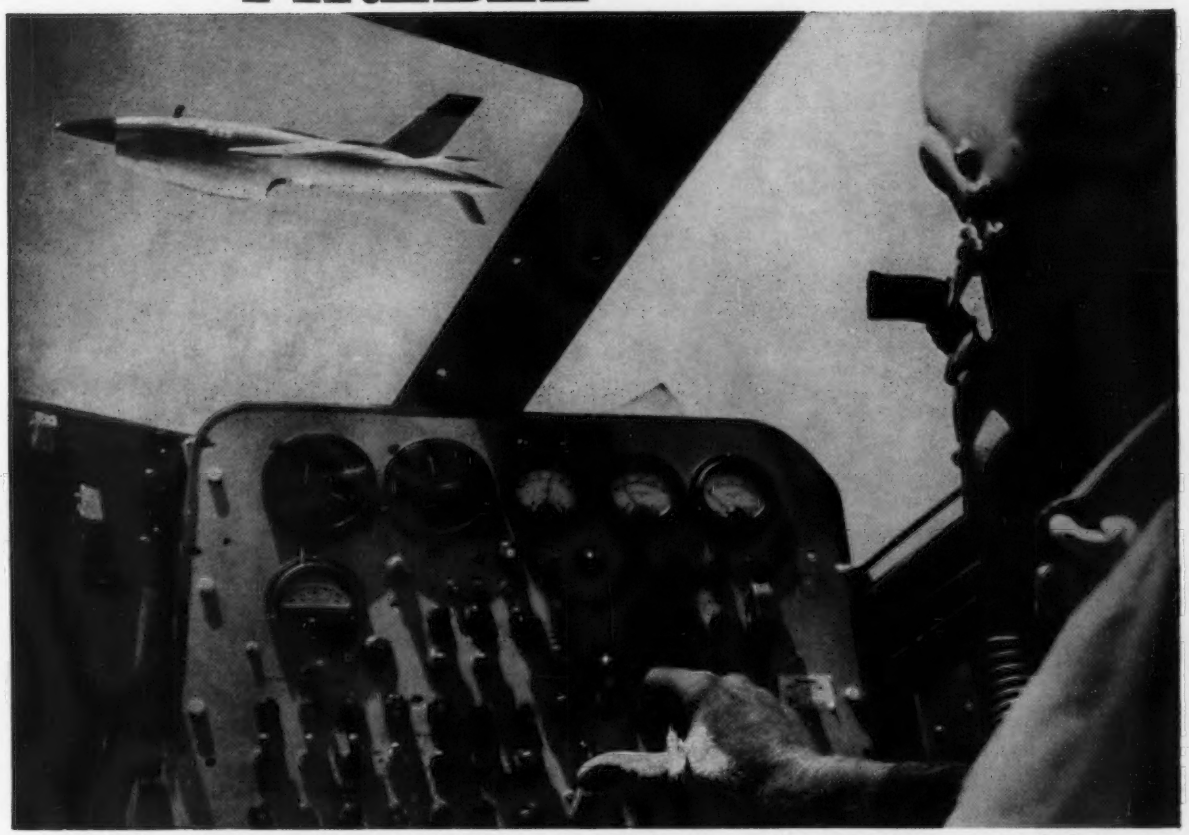


THE VOICE OF THE "FIREBEE"



Firebee is precisely maneuvered by remote controller as he receives flight data transmitted from Dorsett telemetry system in the drone.

Ryan uses airborne telemetry systems by DORSETT

Near-sonic, Ryan's Q-2C "Firebee" Target Drone provides a fast, high-flying, evasive target simulating combat tactics. Rugged and recoverable for reuse, the "Firebee" is daily putting the "test of fire" on American airborne and surface-to-air missile systems.

Firebee can be precisely controlled from airborne or ground stations, since in addition to radar tracking data, engine r.p.m., airspeed and altitude are telemetered continuously to the controller by the Dorsett Model TM-4-31 system.

When additional data is required for missile development programs and special applications, the system may be expanded to a total of ten subcarrier oscillators in the pre-wired chassis.

The Firebee telemetry system is one of the many designed and built by Dorsett Electronics. Put Dorsett's experience to work for you on your next telemetry requirement. Your inquiries and specifications will receive a prompt reply.

DORSETT ELECTRONICS, INC.

P. O. Box 862 • Norman, Oklahoma • JEfferson 4-3750

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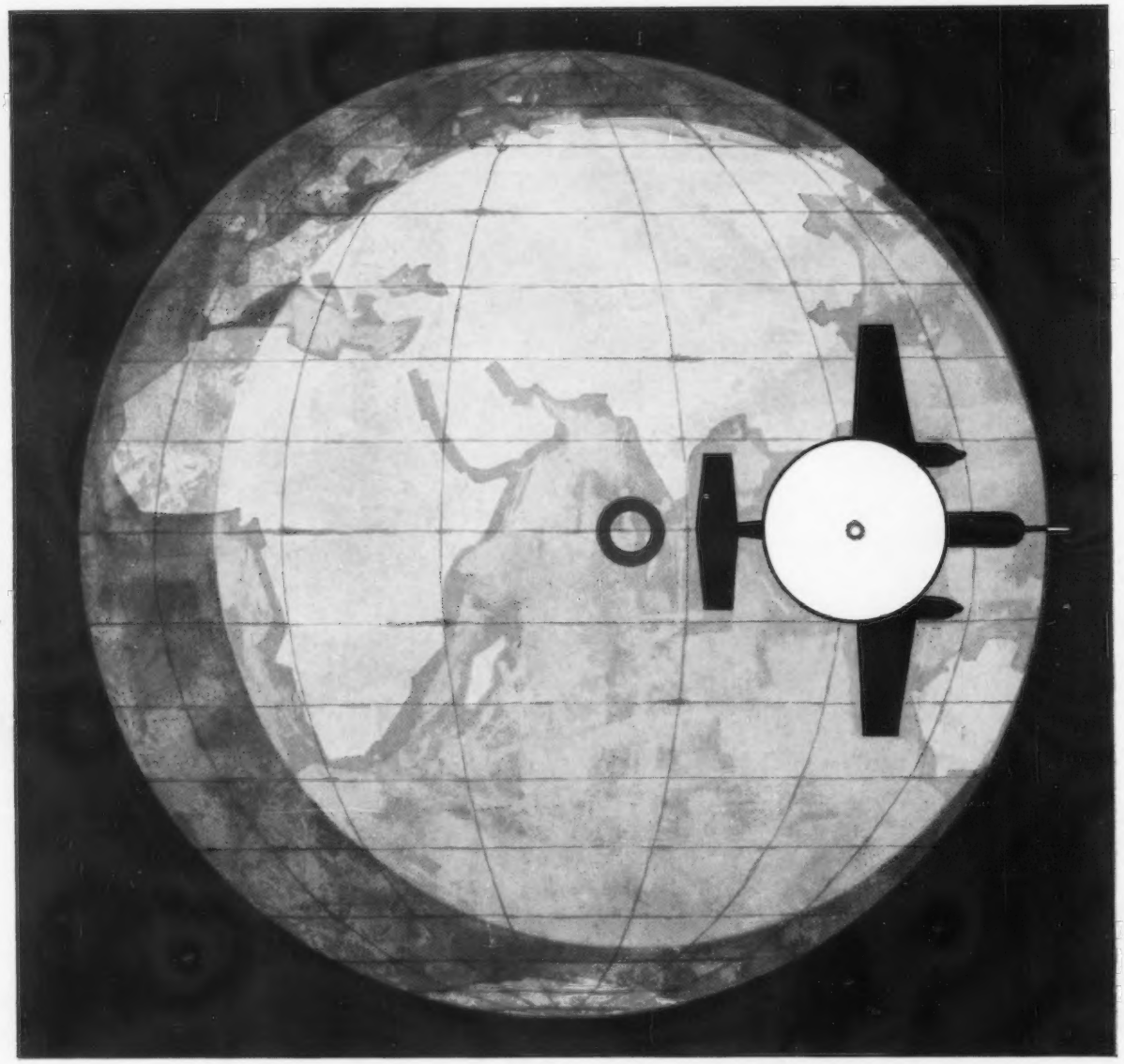

Brunswick Rotodomes - New Eyes and Ears of the Fleet!

Grumman Hawkeye carrier-based A.E.W. aircraft with a Brunswick-built rotodome gives new early warning capability to the Navy.

The Dalmo-Victor Division of Textron Inc. assigned Brunswick the task of fabricating the newest and most sophisticated of rotodomes. Brunswick's vast experience in fabricating large plastic-metal structures of sandwich construction assured the customer and the Navy of receiving a completely reliable product.

This large, complicated structure is another example of Brunswick's capability in the field of reinforced plastics and metal honeycomb. Whether the requirement be for a small structural unit such as a missile radome operating at high frequency, a large composite structure such as the rotodome, large reflectors or ground domes, you can count on Brunswick's project experience to accomplish your most difficult assignments.

In addition, Brunswick offers imaginative scientists and engineers to provide a searching approach to materials and fabrication techniques and electronic know-how. Complete testing and quality control facilities assure the success of all programs.

Interested engineers will find it rewarding to discuss career futures with Brunswick.

MAKES YOUR IDEAS *WORK*

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